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FOUNDED BY C. E. LINEBARGER

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CONTENTS:

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TEACHERS NEED HOBBIES

BY WORRALLO WHITNEY, *Botany Editor*

We all realize that teachers, as well as people in many other lines of work, after working in one subject or one field of work, and often with one grade of pupils for several years are prone to become self satisfied with their work, done over and over again with little variation and with little incentive to widen the view point. Such a state of mind is almost sure to be acquired unless there is something which tends to enrich and broaden the mind, to take the teacher out of his settled routine. We well know that constant exercise of one set of muscles develops these muscles at the expense of the well rounded development that is desirable, tends to give a one-sided symmetry to the bodily powers. In the same way the brain power may become unsymmetrical and even lose of its vigor and alertness.

The best method to counteract this tendency mentioned above is to adopt a hobby or a side line of work for the spare hours. This work may be called an avocation to be pursued along with and supplement the vocation, or bread winning work. The hobby may be in one's own field of work—a research problem for example. It should not be difficult to choose such a problem to study adapted to the conditions under which the teacher finds himself. For instance, the botany teacher has the entire field of ecology and systematic botany open to him. For special lines to adopt for his work, his teacher in his alma mater will be delighted to give advice and help to get started. There are natural history surveys being made in many of the states of the Union. The directors of these surveys will welcome assistant workers and assign problems to study or part of the survey to undertake.

As to papers showing the results of the work when completed, the State Academy of Science welcomes and publishes papers for its members—when read at the meetings of the Academy. This Journal will gladly receive short papers of merit for publication. Many other means of recording and publishing the results of research work may be developed upon inquiry. The avocation adopted if pursued with enthusiasm and persistence may lead to general recognition of its worth among ones co-workers and even may lead to rewards quite unanticipated. This writer has known of cases where the avocation became the vocation as a result of the appreciation of its value. It may also have monetary rewards as this writer has experienced. But the rewards of work at an avocation are not alone the recognition by fellow workers. As the work proceeds one feels a broadening of his powers, his mind is stimulated and quickened so that study over the problem becomes a delight. It enlivens the tedium of the class room routine. Some of this quickened mental alertness will inevitably benefit the work with ones pupils indirectly if not directly.

The field chosen for the avocation need not, of course, lie in the field of the daily routine. It may often to advantage lie in a totally different line. It may fall to the lot of almost any teacher to be assigned to a department of the school work in which he is not interested. The hobby may well, in such cases, give the teacher a chance to keep up his interest in a line of work more to his liking.

There is another advantage not usually thought of. Teachers are human beings and become old and worn out with the school room duties. In many cities and states he must "retire" at a certain specified age. The teacher who has not developed a side line work while younger in which he is interested, and to which he may turn when his time for retirement comes, is to be pitied. It seems fine at first to feel one is not tied to the class room, but this feeling soon passes and the desire to be doing something interesting and worth while takes possession. If there is nothing to meet this situation the joy in the new liberty is soon stale. Even more, the sudden loss of the impelling motive of school work which has occupied the teacher's mind for many years sets him adrift aimlessly without occupation. We know that this inevitably leads to deterioration of both mind and body and a shortened span of life.

IMPROVEMENT SHEET FOR ALGEBRA

By Carl G. F. Franzén, *Indiana University*
Bloomington, Indiana

INTRODUCTION

For the past ten years I have been endeavoring through the assistance of my classes in supervision to develop a series of Improvement Sheets in the various high school subject fields. The idea of the Improvement Sheet is that it may serve as a self-checking device for the teacher, or a basis for observation and discussion of the part of the supervisor.

The main Improvement Sheet indicates that its chief purpose is to find out not only those things which are well done but those things which the teacher seems to neglect. It is in the effort to remedy these conditions that all the statements on the Improvement Sheet have been so worded that the answer yes always indicates a desirable activity, and the answer no, the absence of such desirable activity. Consequently, it may be possible to obtain a profile of all that takes place in the classroom. Since there is still an insufficient amount of experimental evidence upon which to base procedure in Mathematics, we have had to content ourselves with selecting for inclusion in our Improvement Sheets those activities which seem to merit most favorable consideration on the part of the progressive teachers and textbook writers. For this reason these Improvement Sheets of mine or anybody else's can always be criticized by those who know of better practices. Consequently, all that any Improvement Sheet can do is to stimulate teachers or supervisors to consider still better methods of accomplishing their purposes.

It will be noted that the activities of the classroom have been divided into two phases, one of the teacher, and the other of the pupil. Too often we think only of what the teacher does as a criterion of the work of the classroom instruction. It is my contention that an analysis of what the pupils do may often prove a much more challenging critique of classroom instruction.

The references at the end of each Improvement Sheet refer to specific items under the various letter headings and numbered sections. It will be of great help to me to have anyone interested in this problem of developing sheets in Mathematics and the Sciences to refer me to any good references which might be better than those listed.

Aims

1. To develop greater power and skill in computation.
2. To fix habits of checking work.
3. To gain power in use of equation for problem solving.
4. To develop habits of critical thinking and reasoning.
5. To understand mathematical relationships.

Teacher Activity

	Yes	*No*
A. In presenting the new assignment, does the teacher:		
1. Encourage class selection and dictation of demonstration problems?	——	——
2. Permit pupil demonstration with class assistance?	——	——
3. Place the solution upon the blackboard as the pupils direct?	——	——
4. Encourage the discussion of the problem and its solution?	——	——
5. Lead the class discussion of new terms, words, and symbols?	——	——
6. Charge class with correction of misused Algebraic language?	——	——
7. Permit class assistance in the selection of home work?	——	——
8. Secure class judgment relative to number of problems?	——	——
9. Provide "special" problems for retarded pupils?	——	——
10. Provide "extra" work for the accelerated pupils?	——	——
11. Suggest possible outside materials, readings and applications?	——	——
12. Make demonstrations a working-model for the pupils?	——	——
13. Explain new terms and symbols in terms of arithmetic knowledge?	——	——
B. In taking up today's assignment, does the teacher:		
1. Encourage pupil coöperation in problem solving?	——	——
2. Have pupils work problems with him rather than for him?	——	——
3. Encourage free discussion of each problem explained?	——	——
4. Divide the class into competitive groups for drill purposes?	——	——
5. Pass among class giving help when the groups fail?	——	——
6. Encourage the pupils to help each other in finding mistakes?	——	——
7. Review forgotten fundamentals of arithmetic?	——	——
8. Give "chalk-talks" to members of the class?	——	——
9. Introduce "short-cuts" whenever possible?	——	——
10. Formulate simple problems to help overcome difficulties?	——	——
11. Require systematic lettering and numbering of each problem?	——	——
12. Encourage pupils to challenge usefulness of the problem?	——	——

	Yes	*No*
13. Emphasize the "how" more than the "why" of negative numbers?	____	____
C. In securing algebraic motivation, does the teacher:		
1. Rate all home work done by the pupils?	____	____
2. Have pupils graph progress in problem solving?	____	____
3. Display the 3 or 4 best solutions of problems?	____	____
4. Make "honorable mention" of extra difficult problems solved?	____	____
5. Show appreciation for "noble" efforts and achievements?	____	____
6. Show application of each topic to problem solving?	____	____
7. Correlate formulae with science and commerce?	____	____
8. Encourage pupils to introduce puzzle problems occasionally?	____	____

Pupil Activity

D. Do members of the class coöperatively:		
1. Develop new and difficult problems?	____	____
2. Discuss meaning of new terms and symbols?	____	____
3. Criticize the method of problem solving?	____	____
4. Substantiate their criticism with good authority?	____	____
5. Correct improper use of terms and symbols?	____	____
6. Aid each other in problem solving?	____	____
7. Help "slow" pupils to solve their problems?	____	____
8. Recognize practical application when possible?	____	____
9. Check methods and results with each other?	____	____
10. Find mistakes when results fail to check?	____	____
11. Formulate rules from problems just explained?	____	____
12. Use knowledge of arithmetic to overcome difficulties?	____	____
E. Do pupils discuss and analyze story problems by:		
1. Stating all elements of the problems?	____	____
2. Stating the relation of these elements to each other?	____	____
3. Making an equation from these equal elements?	____	____
4. Translating the equation into algebraic language?	____	____
5. Making drawings or illustrations of the problem?	____	____
6. Using capital letters to represent vertices?	____	____
7. Using small letters to represent the lines?	____	____
8. Discussing the best method to use in solution?	____	____
9. Estimating the probable results?	____	____
10. Noting the relation between numbers?	____	____
11. Keeping a list of all new words and terms?	____	____
F. In solving the problems, do the pupils:		
1. Use first letter of element to represent unknown quantity?	____	____
2. Arrange unknowns in alphabetical order?	____	____
3. Arrange exponents in ascending-descending order?	____	____
4. Carefully letter steps to indicate operation in solution?	____	____

	Yes	No
5. Number each step in order to readily locate all errors?	——	——
6. Keep the equal signs in vertical order?	——	——
7. Secure all possible results to the problem?	——	——
8. Make a written explanation of each answer obtained?	——	——
9. Check each answer with the original equation?	——	——
10. Use uniform paper for problem solving?	——	——
11. Make neat arrangement of all written work?	——	——
12. Discuss all results obtained?	——	——

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[This improvement sheet is now in the process of revision and the author solicits your help in the selection of references.—ED.]

FROM THE SCRAPBOOK OF A TEACHER OF SCIENCE

BY DUANE ROLLER
The University of Oklahoma, Norman, Okla.

We believe that in an industrial laboratory, the physicist or engineer who has the fundamental classical background is of greater value than a physicist who has almost exclusively specialized in the modern physical developments.—*Dr. Frank B. Jewett, President of the Bell Laboratories, in "School and Society," 31, 415 (1930).*

I believe I am not overstating the truth when I say that half the time occupied by clerks and draftsmen in engineer's and surveyor's offices—I am sure at least one-half of it—is work entailed upon them by the inconvenience of the present farrago of weights and measures.—*Lord Kelvin.*

The most important step in the progress of every science is the measurement of quantities. Those whose curiosity is satisfied with observing what happens have occasionally done service by directing the attention of others to the phenomena they have seen; but it is to those who endeavor to find out how much there is of anything that we owe all the great advances in our knowledge.—*Clerk Maxwell, in "Theory of Heat."*

There's no expedient to which a man will not go to avoid the labor of thinking.—*Thomas A. Edison.*

If you make people think they think, they'll love you. If you really make them think, they'll hate you.—*Don Marquis.*

How index-learning turns no student pale,
Yet holds the eel of science by the tail.
—*Alexander Pope, in "The Dunciad," Book 1.*

If you want to get results—experiment, and nature talks to you; don't experiment with lead pencils.—*Thomas A. Edison.*

SCIENCE HEADS

By L. W. Applegarth
Whiting High School, Whiting, Indiana

The following questions were submitted in a questionnaire to two-hundred twenty-six superintendents of schools in order to study the status of science department heads in the high schools of six states. Seventy-nine and six-tenths per cent of all questionnaires submitted were returned to me. If you have a science department head,

1. Was he recruited from your science faculty?
2. What subjects does he teach?
3. How many class hours each week?
4. What other specific duties has he?

Population	Number of cities	Letters sent	Replies	Per cent of replies	No Science Head	% reporting no Science head	Recruited from Science Faculty			Subjects taught					
							I			II					
							Yes	Ind	No	C	P	Bio	B	Z	O
5000 10000	190	47	41	87.2	31	75.6	10	0	0	5	7	1	0	0	2
10001 20000	102	60	45	75.0	30	66.6	10	2	3	10	7	0	3	2	4
20001 30000	37	35	30	85.7	19	63.3	9	0	2	1	4	1	1	0	2
30001 40000	24	24	19	79.1	12	63.1	6	1	0	2	3	0	1	0	0
40001 50000	16	16	9	56.2	1	11.1	6	2	0	3	2	0	2	1	0
50001 60000	12	12	12	100.0	4	33.3	6	1	1	4	3	1	1	1	1
60001 70000	9	9	7	77.7	2	28.6	5	0	0	3	4	0	0	1	0
70001 80000	3	3	3	100.0	0	0	2	1	0	2	2	0	0	0	0
80001 100000	2	2	2	100.0	0	0	2	0	0	0	0	0	1	0	0
100001 200000	9	9	5	55.5	1	20.0	4	0	0	1	2	0	0	0	1
200001 and up	10	9	7	77.7	2	28.6	5	0	0	1	0	0	0	0	2
Totals	414	226	180	79.6	102	56.6	65	7	6	32	34	3	9	5	12
Averages															

5. What is his salary range?
6. How much specialized training has he beyond the bachelor's degree?
7. Would you care to have a copy of the tabulated results of this study?

Data covering these questions are arranged in the table under the following headings:

1. Population of city.
2. Total number of cities in each group.
3. Number of letters sent.
4. Number of replies.
5. Percentage of replies.
6. Number of cities reporting no science head.
7. Percentage of replies reporting no science head.
8. Question (1) of the questionnaire divided into three parts, viz: yes, indefinite (I), no.
9. Question (2) of the questionnaire divided into six parts, viz: chemistry, (C), physics, (P), biology, (Bio), botany, (B), zoology, (Z), and other subjects (O).

Class hours			Salary Range			Training Beyond the Bachelor's Degree			
III			V			VI			
Low	Av.	High	Low	Av.	High	None	0–½ yr.	½–1 yr.	more than 1 yr.
20	25	35	1530	2300	3600	1	3	3	3
15	22	30	1350	2216	3600	2	1	11	1
3	21	30	1800	2440	4350	1	2	7	1
15	21	38	2300	2700	3500	0	1	4	2
5	22	32	2100	3200	5400	0	1	5	2
7	16	25	2000	3006	4600	0	1	2	5
4	16	28	2000	3400	5000	0	0	3	2
15	21	28	1800	2262	3050	0	1	2	0
5	13	20		2500		0	0	1	1
5	19	28	1800	3212	3750	0	0	3	1
4	17	25	3040	3377	3800	0	0	5	0
						4	10	46	18
8.9		28	1972		4065				

10. Question (3) of the questionnaire divided into three parts, viz: low, average (av), and high.

11. Question (5) of the questionnaire divided into three parts, viz: low, average (av), and high.

12. Question (6) of the questionnaire divided into four parts, viz: no training, no training to one-half year, one-half to one year, and more than one year.

SPECIFIC DUTIES

The specific duties as listed in the returned questionnaire are many and varied. Replies coming from cities ranging from five thousand to ten thousand population include the following: he has charge of lockers in high school; he is faculty representative for all school publications; advertising; he has laboratory care and upkeep; he makes recommendations for supplies; he is assistant football coach; he has several minor duties; his business is chiefly teaching.

Cities ranging in population from ten thousand to twenty thousand report the following specific duties: supervises course of study construction, glee club, music, assistant principal, athletic manager, calls department meetings, directs a tumbling team, dean of boys, junior class basket ball coach, supervisory, home room duties. Here is a strange mixture of specific duties some of which are administrative and supervisory in character.

Cities between twenty thousand and thirty thousand population list the following specific duties about half of which pertain to administrative and half to supervisory activities: he advises other science teachers, directs science curriculum to keep general outlook on department, administration work, enrollment and program, organization, unit planning.

Among the reports from cities between thirty thousand and forty thousand, we find the following specific duties reported which show an increase in the supervisory and administration duties of science heads in cities of this size over smaller cities: supervisory, assistant principal, supervisor of elementary science, junior class adviser, outlining science work and meeting teachers.

Beyond this point, the specific duties of science heads decidedly favor administration and supervision, either within the science department, or with reference to the general administration of the school. The following specific duties will illustrate this point: duties ordinarily given to a head of department, supervision, assistant principal, general oversight and general

duties as responsible head, vice principal, assistant administrator, preparing courses of study, carrying out monthly testing program, advising students, in charge of all science teaching. He makes up or supervises all examination questions, course of study, methods of teaching, supplies and equipment, coordination of teachers in his department, prepares objective standards of achievement and makes report on progress made. He supervises all elementary, junior, and senior mathematics and all sciences; he helps to make course of study; he is supervisor and assistant principal; he is supervisor for junior and senior high schools and director of science.

SUMMARY

Cities of five thousand to ten thousand population report 75.6% having no science head, while those between ten thousand and forty thousand report having no science head ranging from 66.6% to 63.1%. 11.1% of cities ranging from forty thousand to fifty thousand population report having no science head; those cities of fifty thousand to sixty thousand and sixty thousand to seventy thousand report 33.3% and 28.6% having no science head respectively. Cities between seventy thousand and one hundred thousand have 100% science heads, while cities from one hundred thousand to two hundred thousand report 20% as having no science head. Cities from two hundred thousand up report 28.6% as having no science head.

Subjects most frequently taught by science heads are as follows: physics 35.7%, chemistry 33.6%, other subjects 12.6%, botany 9.4%, zoology 5.2%, and biology 3.1%.

The actual number of hours spent in teaching ranges from three to thirty-five weekly. This variation is due to administrative and supervisory duties. The low average is 8.9 hours weekly; the high average is 28.0 hours weekly.

The low salary average for all groups is 1972 dollars; the high salary average for all groups is 4065 dollars.

Seventy-eight science department heads reported their training beyond the bachelor's degree. Of this number, four (5.1%) report no additional training; ten (12.8%) report up to one half year; forty six (58.6%) report from one half to one year additional training; and eighteen (23.0%) report more than one year.

Practically all participants in this questionnaire expressed a desire to have a copy of the tabulated results of this study.

A STUDY OF EXISTING SCIENCE CLUBS AS PORTRAYED BY CURRENT SCIENCE MAGAZINE ARTICLES

By Ethel L. Roberts, *Junior High School Clairton, Pennsylvania*

This study was made at the University of Wisconsin during the summer session of 1931. An analysis was made of 35 separate periodical articles written on the subject of science clubs and published in the following magazines: School Science and Mathematics, *Science Education* (General Science Quarterly), *Current Science,* and the *Chemical Leaflet.* The articles are representative of the science club movement from 1914 to 1931. From these articles sixteen were selected as dealing with specific science clubs. These articles were critically examined in an effort to find items that were of concern in the organization and management of science clubs.

The problem was to determine: (1) on the basis of frequency (from the information given in reports of various science clubs in current magazines) the items the writers seem to consider worthy of mention, (2) to what extent these items might be effective in assisting in the organization of science clubs on the part of new workers in the field and in improving science clubs already in existence, and (3) what a helpful article dealing with a science club should contain. All items given were tabulated according to the plan below. The items were then arranged according to the frequency of mention in the articles. For example: if mention of types of programs, in general, was made in all articles, this item was scored 16. Then under this heading, if "pupil discussion" as a special type of program was mentioned in 12 articles, this type of program was scored 12, and so forth, with all of the articles.

GROUP TABLE OF FINDINGS

Items	*Frequency*
1. Types of Clubs	16
(1) General Science Clubs	9
(2) Chemistry Clubs	2
(3) Biology Clubs	1
(4) Bird Clubs	1
(5) Service Clubs	1
(6) Vocational Clubs	1
(7) Wireless Clubs	1

2. Objectives	11
(1) To arouse, in the pupil, an appreciation of his environment	4
(2) To stimulate interest	4
(3) To supply an outlet for the activities of the adolescent	3
(4) To promote opportunity for social contact	3
(5) To increase desire for further information	3
(6) To promote service and coöperation	3
(7) To offer material for vocational value	2
(8) To suggest worthy use of leisure time	2
(9) To develop initiative	2
(10) To offer opportunity for self-expression	1
(11) To develop the scientific method	1
(12) To establish moral values	1
(13) To develop responsibility	1
(14) To offer training in public speaking	1
(15) To supplement the work of the classroom	1
(16) To adopt no definite hobbies	1
3. Constitutions	2
4. Membership	10
(1) Open to all members of subject	2
(2) From 20 to 30 members	2
(3) From 30 to 40 members	0
(4) From 40 to 50 members	2
(5) From 50 to 60 members	2
(6) From 60 to 70 members	1
(7) From 70 to 80 members	1
(8) From 80 to 90 members	1
(9) From 90 to 100 members	0
(10) Above 100 members	1
5. Officers	8
(1) Regular officers (Pres., Vice-Pres., Sec., Treas.)	7
(2) Faculty Advisers	3
(3) Sergeant-at-arms	1
(4) Librarian	2
(5) Scouts	1
(6) Special committees	4
(7) Editors	1
6. Time of Meetings	5
(1) During school hours	4
(2) After school hours	1
7. Frequency of Meetings	12
(1) Once a week	5
(2) Once every two weeks	4
(3) Changeable	2
(4) Once every six weeks	1

8. TIME ALLOTTED FOR MEETINGS	4
(1) One period	1
(2) Forty-five minutes	1
(3) Fifty-five minutes	1
(4) One hour	1
9. TYPES OF PROGRAMS	16
(1) Lectures	16
a. Outside speakers	7
b. By students	3
c. By teachers	2
d. Illustrated lectures	2
e. Not specified	2
(2) Demonstrations	8
a. Pupil demonstrations	2
b. Teacher demonstrations	1
c. Not specified	5
(3) Discussions	6
(4) Slides and	4
(5) Assembly programs	4
(6) All Student Programs	3
(7) Reports	3
(8) Entertainments	2
(9) Music	2
(10) Plays	2
(11) Actual work	1
(12) Question Box	1
(13) Readings	1
10. BUSINESS MEETINGS	2
11. OTHER ACTIVITIES	14
(1) Excursions or trips	7
(2) Picnics, parties, dances, and other social affairs	5
(3) Problems and projects	4
a. Constructing amplifiers	2
b. Acting as electrician for plays	2
c. Operating motion picture machines	2
d. Making slides	1
e. Assisting with photography department	1
f. Operating amateur radio stations	1
g. Publishing a journal	1
h. Setting up and repairing apparatus	1
i. Setting up a sun dial	1
j. Making receiving sets	1
(4) Civic Work	3
(5) Contest	2
(6) Affiliation with other societies	2
(7) Bazaars	1
(8) Exhibits	1
(9) Puzzles	1

12. DUES	9
(1) Dues, but no amount stated	1
(2) Fifty cents per year	1
(3) One dollar per year	1
(4) Twenty cents per year	1
(5) Twenty-five cents per semester	1
(6) Five cents per week	1
(7) Occasional tax	1
(8) Thirty-five cents for the first year, then ten cents for juniors and five cents for seniors	1
(9) Nominal	1
13. INSIGNIAS (Pins and colors)	1
14. DIFFICULTIES	2
(1) Prime movers of group lose influence on majority and others feel outclassed	1
(2) Progress of few leaders soon exhaust source material	1
(3) Time too short	1
15. RESULTS	4
(1) Created interest	2
(2) Supplemented work of the class	2
(3) Doubled number of clippings for bulletin board	1
(4) Increased supplementary work	1
(5) Resulted in better relationship between teacher and student	1
(6) Increased self activity	1
(7) Afforded opportunity for self-expression	1
(8) Satisfactory results	1

GENERAL CONCLUSIONS

The outcome of the investigation seems to justify the following conclusions:

1. On the basis of frequency, the writers of the science club articles seem to consider as worthy of mention:

(1) Types of clubs	16
(2) Types of programs	16
(3) Other activities	14
(4) Frequency of meetings	12
(5) Objectives	11
(6) Membership	10
(7) Dues	9
(8) Officers	8
(9) Time of meetings	5
(10) Time allotted to meetings	4
(11) Results	4
(12) Difficulties	2
(13) Business	2
(14) Constitution	2
(15) Insignias (Pins or Colors)	1

2. The information given by these various articles does not seem adequate in meeting the needs of new organizers in the field, or in offering assistance to present directors. The various items listed do not occur frequently enough in most cases to justify the new organizer in deciding whether or not the particular item is of vital importance in the organization of a club, and in most cases the items listed are not complete in description.
3. A good helpful article dealing with the subject of science club organization should include the following information with substantiating evidence:
   (1) Method of selecting name and insignia for club
   (2) Aims and objectives stated in order of importance
   (3) Organization of the club
      a. Method by which constitution was drawn up
      b. Officers and duties of each
      c. Membership—requirements and limitations
      d. Time and frequency of meetings.
      e. Length of meetings
      f. Business procedure
      g. Dues
   (4) Types of programs, with typical one given
   (5) Other activities—service or social
   (6) Results obtained
   (7) Difficulties encountered

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MEXICAN SOLDIERS FOUGHT LOCUSTS

Mexican military forces combatted the locust plague in southern Mexico this summer. Various swarms of insects invaded the coastal plain of Chiapas from over the border of Guatemala during May and June. More than 50,000 pounds of the subsequently breeding "hoppers" were killed by the soldiers, who trapped them in trenches. It takes about 7,000 young insects to make a pound.

The locusts maturing from the escaped "hoppers" in the course of the campaign flew into the mountains, and a serious plague of the pests may be feared next season.

Three inspectors of the Mexican Ministry of Agriculture directed the campaign, and by presidential decree soldiers stationed in the state assisted them.

A COMMON SENSE BASIS OF CHEMISTRY TEACHING IN SECONDARY SCHOOLS

Part II. Suggestions for Improvement of Laboratory Methods

By G. T. Franklin
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In a previous paper the soundness of the principle of individual laboratory work in secondary schools was stressed and the need for closely correlated demonstrations mentioned. The purpose of this paper is to discuss briefly the kind of experiments best adapted to individual laboratory work and suggest some ways for improving it.

The immediate object of the laboratory work should be:

(1) To develop skill in assembling and using apparatus;

(2) To make the finding of facts impressive and interesting;

(3) Better to get into the spirit of chemists by going through the motions of chemists;

(4) To discover principles and relationships, to encourage the development of originality and inventiveness;

(5) To cultivate habits in cooperation, the preservation of property, in short the cultivation of good citizenship practices.

LEARNING TECHNIQUE

Such fundamental processes as the proper insertion of glass tubing through rubber stoppers, the bending and polishing of glass tubing, the folding and insertion of filter papers into funnels, etc. are learned in two steps. The first step consists in watching the teacher do them. The second step is the pupil's own efforts to do the thing for himself. Many pupils think it is easy to do when they see the teacher do it, but work very awkwardly when they attempt to do it. To assemble apparatus is of little value unless it is used to do experiments. Youth loves to put tools to work and is not satisfied with process of merely putting things together.

FACT-FINDING

The objection may be made that the study of properties of such common substances as hydrogen, oxygen, and chlorine by individual laboratory work is wasteful of time when such facts are readily obtainable from books. If the study of chemistry were based upon the sole purpose of learning facts and solving arithmetic problems, all laboratory work could be

economically dispensed with. To learn important facts by the laboratory method carries with it an interesting way of doing it and when the information is organized in a systematic way, training in the first principles of the scientific method is started.

GETTING INTO THE SPIRIT OF CHEMISTRY

The pupil should be more interested in decomposing mercuric oxide after studying the story of Priestly. On the other hand the work of Lavoisier should be more interesting to read about after work with burning metals has been done. To ignore the history of equivalent weights (1) and fail to relate laboratory work of the replacement type to it, is a failure to vitalize the work. The study of ions, atoms, and molecules may be made more realistic through this type of experimental work. The laboratory should be made the basis of motivated effort. Such experiments as the dry distillation of coal (2) have many possibilities. If the distillation of coal is carried out with tests for sulfur in the gaseous part, ammonia in the gas and in the coal tar, it forms a basis for class discussion of fuel gases, and other topics of vital importance in industry. Without experimental background the lectures are prone to lack interest and are soon forgotten.

THE SPIRIT OF DISCOVERY

That the laboratory work of beginning students of chemistry needs close supervision is apparent. To turn loose a pupil in a chemical laboratory with the instruction "to find out for himself" would be silly. The geniuses of the race lived and died through long periods of time without discovering some of the simplest principles, although they were constantly in contact with them. The life of the individual is too short to repeat the experiences of the race. The education of people depends largely upon their ability to learn new facts with speed. If, on the other hand, the method of discovery is left entirely out of the work, future progress will be limited. In the laboratory work there are many opportunities to give work to test the ability of pupils to do original thinking and give training in the observation of facts, which lead to discovery of principles. To give correct impressions and sound generalization, thoroughness should be stressed. Thus, if the reaction of hydrochloric acid with metals is studied and only positive reactions are used, the information is not only incomplete but it may lead to wrong conclusions. To rectify this, testing should cover a rather wide range including

both positive and negative results. (3) Even this far may give the false impression that when an acid reacts with a metal hydrogen is always obtained. An experiment that ends with the preparation of borax or metaphosphate beads of brilliant colors is incomplete at its best. When the pupil has experimented with those metal ions that do not give any color to the bead and his attention is called to the valences of the metal ions that do and do not give color, he should discern the fact that color formation is related to valence. This important generalization may be used to study those brilliant colors known as Prussian and Turnbull's blues. He is started in that important part of chemistry connected with the theory of dyes; motivation is present.

The study of baking powders offers an opportunity to present many fundamentals of chemistry and opens up a chance to teach the method of assembling data to the best advantage. Hydrolysis is one of the big topics involved in the study. This problem has always been regarded as one of the hardest for the beginner in chemistry. However, to shirk it means the study of this practical topic must be eliminated altogether or merely touched upon in a descriptive way. Many pupils come to the chemistry classes with the idea that litmus tests are final tests for acids and bases. To learn to use scientific definitions is one of the valuable assets of a course. To establish a basis for understanding and use of a definition of a base, all through the beginning part of the course emphasis should be placed upon the idea that hydrogen ions turn litmus red and hydroxide ions turn litmus blue. The pupil may have had some work on hydrolysis before the problem of baking powders is reached; if so, all the better. A study of ionization and the meaning of such terms as "strong acid" and "weak acid" learned preferably through conductivity experiments must precede the study. The study of reactions involving the production of carbon dioxide by addition of acids to metal carbonates generally precedes the work on baking powders. The beginning is made by directing the class to dissolve some baking soda in water and test the solution with litmus papers. The equation may be written for the pupils with the understanding that ions are to be used to indicate strong electrolytes and molecules weak electrolytes:

$$Na^+ + \overline{HCO3} + HOH \rightleftharpoons H2CO3 + Na^+ + \overline{OH}.$$

Such questions as the following should be used to lead the pupil: Does any gas form? If the reaction went to an end from left to

right would a gas form? What is the tendency to cause the reaction to go from left to right? What counter influence tends to prevent the reaction from going from left to right? Is there evidence that any reaction takes place? Does the equation fit the facts?

After the above work is completed aluminum sulfate may be dissolved in water and the solution tested with litmus as before. The equation may be written as follows:

$$2Al^{+++} + 3SO4^{--} + 6HOH \rightleftharpoons 2Al(OH)3 + 6H^{+} + 3SO4^{--}.$$

The method of questioning used above should be applied: If the reaction went to an end from left to right, what precipitate would be expected? Does the precipitate form? Is there any evidence of chemical reaction? What tends to influence the reaction to go from left to right? From right to left? Why write the formula of aluminum hydroxide molecular and not with ions? Does the equation fit the facts?

The study of this fundamental principle may be continued by requiring the class to dissolve sodium sulfate in water and to test the solution with litmus papers as before. The equations may be written in the hypothetical form and the pupil asked to use his judgment in deciding which to use as follows: Possible reactions are:

$$(1)\quad 2Na^{+} + SO4^{--} + 2HOH \rightleftharpoons 2NaOH + 2H^{+} + SO4^{--},$$

$$(2)\quad 2Na^{+} + SO4^{--} + 2HOH \rightleftharpoons H2SO4 + 2Na^{+} + \overline{2OH},$$

$$(3)\quad 2Na^{+} + SO4^{--} + 2HOH \rightleftharpoons 2H^{+} + SO4^{--} + 2Na^{+} + \overline{2OH}.$$

Again question should be applied to assist the learner: What are the objections to some of these equations? Does the litmus test prove all of them wrong? Which one fits the facts better than the others? Is a neutral solution one which has no hydrogen and hydroxide ions or one containing equal numbers of hydrogen and hydroxide ions?

A brief review of acids salts is not out of place. The definition of an acid salt is studied and applied. The pupil is likely to think that aluminum sulfate is an acid salt and baking soda a basic salt. Potassium bitartrate may be used as an example further to illustrate acid salts. If this material is dissolved in water and the pupil asked to test the solution with litmus and then write an equation to fit the facts, the poorer students will in variably use the same method as for baking soda. Further

work with solutions of monosodium phosphate and disodium phosphate should be used. If litmus tests are applied and then equations required, the effectiveness of the teaching by the first part of the work is determined. The class should now be asked to tabulate results after completing the tests with litmus papers and then with sodium bicarbonate as follows:

Solution Used	*Litmus Test*	*Produces CO2 or Does not Produce CO2 with NaHCO3*
Sodium sulfate		
Aluminum sulfate		
Sodium aluminum sulfate		
Alum		
Monosodium phosphate		
Disodium phosphate		
Monocalcium phosphate		
Potassium bitartrate		

The pupil should discover by the time he completes this work that only those substances in solution that show free hydrogen ions present produce carbon dioxide with baking soda. If this is not apparent, the questioning should continue: What ionic substance could be introduced into a baking soda solution that would remove the hydroxide ions? What is the effect upon the equilibrium of the baking soda reaction with water of the removal of hydroxide ions? What experimental fact indicates that the reaction goes to an end when hydroxide ions are removed?

With this preliminary work at an end, the teacher should be in a position profitably to develop the topic of commercial baking powders. If time affords a laboratory problem involving the analysis of common types of commercial baking powders is of unfailing interest.(4)

It is equally important in the study of hard waters to approach the problem through the laboratory.(5) Again, definitions are important. The composition of an ordinary commercial soap should be briefly studied and the use of the soap in testing for hardness in water made. Pupils are prone to think that water containing calcium hydroxide in solution is soft water because it is sometimes used for medical purposes. On the other hand sodium hydroxide, because of its corrosive nature, is to him hard water. To get wrong impressions out of his mind and definitely fix others of a scientific nature, numerous tests should be required. Emphasis should be made upon the fact that lather in a test tube persists while foam rapidly subsides. The differ-

ence between foam and lather foam, and precipitate should be likewise emphasized. A list of solutions suitable to the purpose is suggested as follows:

Solution Tested	*Test Shows Hard or Soft*
Washing soda	
Limewater	
Potassium hydroxide	
Ferrous sulfate	
Borax	
Magnesium sulfate	
Ammonia water	
Calcium sulfate	

Further work of a general nature may be done to stress the chemistry of soap and reactions involving it. If a few drops of hydrochloric acid are added to some soap solution a white precipitate, identified as a fatty acid, forms. The solution no longer lathers when shaken. The addition of a few drops of sodium hydroxide solution dissolves the precipitate and the lather returns. Equations for these reactions may be written with profit as well as others involving the formation of insoluble magnesium and calcium soaps. From the laboratory work the pupil should learn that sodium, ammonium, and potassium compounds do not harden waters and that metal ions of valence two or more invariably produce hardness in water. The foundation for a study of hardness in natural waters is laid by this work and the study including this work should be made profitable and interesting. Objections may be made that such studies require so much time. The answer is that it is far better to study a few topics right than to do superficial work in many.

The topics discussed probably include some of the best adapted to laboratory work, best fitted to interest individuals to further laboratory exploration and problem solving. It is more than possible that even better ones exist, however, and chemistry teachers can do much by keeping an eye open to their detection.

Another paper will follow in which is discussed the use of laboratory demonstration work in the teaching of beginners in general chemistry work.

Suggested Readings

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100,000 JOBLESS GRADUATES USE "RAIN CHECKS" ON HIGH SCHOOL DIPLOMAS

One hundred thousand unemployed young men and young women high school graduates are using "rain checks" on their high school diplomas, according to the Federal Office of Education.

To high school principals and teachers has fallen a major task—that of sustaining the morale of this vast army of alumni, the majority of whom are in quest of something to do until they can find jobs or can see their way clear to return to or enter college.

The urgency of the post-graduate problem was disclosed recently in answers to letters from United States Commissioner of Education, Wm. John Cooper, asking what schools are doing to help the unemployed. Many superintendents reported three and four times more post-graduates in school this year than were enrolled a few years ago. One city, Minneapolis, Minn., reported 505 graduate students using high school "rain checks." High school registration of former graduates has increased 800 per cent throughout the United States in the last 10 years, it has been learned.

The past year has witnessed a greater jump in the number of post-graduates enrolled in America's high schools than ever before, due, it is believed to a plea of the President's Committee on Unemployment Relief for high school graduates to return for further study and to remain out of the job market during the business lull.

To meet the emergency, high school principals had to change their school programs very materially, records show. Many in under-staffed schools are using returned alumni members as secretaries, assistants to teachers struggling with large classes, assistant coaches or helpers in janitorial or lunch-room service, in an endeavor to make the former students "assets" instead of "liabilities" to the school budget. Standing in this way somewhat above the rank of pupil, post-graduates retain their self-respect, at the same time gladly giving service for the privilege of receiving additional education.

Most principals are allowing the increasing numbers of post-graduates as much freedom as possible to work toward their objectives "under their own steam." They furnish sufficient counseling to guide them in the proper direction, and then let them work out their own problems.

Correspondence courses are being used in some schools, to give the student a wider selection of studies than could otherwise be supplied, and allow him to take several chosen courses under the supervision of one teacher. Extension courses offered for local study by State universities have also been found useful by many jobless high school graduates.

Junior college enrollments have been greatly increased this year, and cities having junior colleges report few post-graduates attending classes in high school.

THE THEORY OF RELATIVITY

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The three stages in the development of the theory are (1) the special theory, 1905; (2) the general theory, 1916; (3) the unified field theory, on which Weyl, Eddington and Einstein have been working since 1918.

The primary difficulty in the understanding of the theory is philosophical. The theory of relativity involves a revision in the concepts with which we interpret the physical world. One must change one's ways of looking at things. Most of our action and thinking is habitual. All teaching of elementary physics, in high schools and colleges, is the inculcation of classical ideas. Hence in order to understand the theory of relativity one must free oneself from one's habits.

I begin the discussion with an analysis of the nature of physical concepts. The physicist talks about length, time, mass, force. What does he mean? Consider, for example, the concept of mass. According to classical ideas mass is the quantity of matter in a body. The relativistic theory would admit that the term mass refers to some property of a body, but in physical theory the word mass applies to a number which is assigned by certain operations. Now a quantity of matter was conceived of as an absolute, independent reality, the number assigned by a measurement requires a standpoint. Thus the distinction between the classical and relativistic interpretations of mass and other physical quantities is that between absolutistic and relativistic, realistic and operational, points of view. The distinction between the two modes of interpretation may be further explained by analyzing a physical law such as $F=ma$. According to the absolutistic point of view an activity (force) acts on a quantity of matter (mass) and produces an acceleration therein. Thus the equation states that the quantity of activity is equal to the quantity of matter times the acceleration. According to the operational point of view the proposition states that it is possible to assign numbers, F, m and a such that $F=ma$. The numbers are relative to certain standards of measurement and frames of reference.

Before setting forth the theory of relativity it will be desirable to outline the concepts of classical mechanics.

Mechanics is the science of motion. Now motion is change of

position in space with time. The description of motion depends upon a frame of reference. Suppose, for example, that a man is in a car which is moving with respect to the earth. He drops a stone out of the window. What is the motion of the stone? With respect to the car as frame the stone moves in a straight line. With respect to the ground as frame the stone moves in a parabolic path. Thus in order to describe motion we must specify the frame of reference.

Also we need a measuring rod to measure distances and a clock to measure time.

Classical mechanics was based upon absolute time and absolute space. The proposition, event A is simultaneous with B, was supposed to hold in all frames. Simultaneity is absolute. The time t of an event was the same for all frames. Thus time was held to be absolute. Again, the distance between two points was held to be the same for all frames. The length of a rod was the same for all frames. Space and time were absolute.

In terms of these concepts Newton expressed the laws of classical mechanics. For example, the first law states that a body under no forces moves with uniform rectilinear motion. The second law is $F=ma$.

Now the classical mechanics satisfied a principle of relativity of uniform motion. This principle is as follows: Suppose that the laws of mechanics hold with respect to a system K. Then they hold with respect to any system K' which has a constant velocity with respect to K. Now for most practical purposes the earth is a satisfactory frame K. Thus the principle of relativity of uniform motion states that a frame which moves with constant velocity with respect to the earth is also a permissible frame. For example, the laws of mechanics hold in a car that is moving uniformly with respect to the earth. For this reason one can play billiards or tennis in a car traveling with uniform rectilinear motion. The practical consequence of the principle of relativity is that one can not detect a uniform motion of a frame of reference.

Now all motion is relative in the sense that it must be referred to a frame of reference. But when one says that in classical mechanics uniform motion is relative one means that the motion may with equal justification be referred to any one of a set of frames which move uniformly with respect to each other. For in classical mechanics the uniform motion of a frame of reference is indeterminate. The acceleration of a body is the

same with respect to all permissible frames and in this sense acceleration is absolute.

During the nineteenth century there was a development of electromagnetic theory. This theory was developed upon the assumption that electromagnetic processes have their seat in a fixed ether. The ether furnished the proper frame of reference for electromagnetic phenomena. A fundamental principle was the principle of the constancy of the velocity of light. This velocity c was assumed to be measured with respect to the ether. Thus the principle of relativity of uniform motion of classical mechanics was abandoned in electro-magnetic theory. If phenomena are studied in a system which is moving with respect to the ether they will reveal the motion of the system with respect to the ether. Now it is reasonable to assume that the earth is moving with respect to the ether. Hence relative to the earth the velocity of light will depend upon direction. Let K be a frame at rest in the ether; let the earth be moving with velocity v with respect to K. In the direction of motion of the earth the velocity of light relative to the earth is $c-v$. In the opposite direction the velocity of light is $c+v$. Thus measurements of the velocity of light in different directions with respect to the earth should reveal the motion of the earth with respect to the ether. An experiment for the purpose of detecting the motion of the earth with respect to the ether was performed by Michelson and Morley in 1881. The result was negative. Thus experiment failed to reveal the motion of the earth relative to the ether. The principle of relativity of uniform motion was thus verified for electromagnetic theory. But this contradicted the principle of the constancy of the velocity of light relative to the ether.

The function of the special theory of relativity was to extend the principle of relativity of uniform motion to include electromagnetic phenomena. Einstein abandoned the ether and assumed both the principle of relativity and the principle of the constancy of the velocity of light. The union of these two principles has as consequence that the velocity of light is the same in all permissible frames of reference. The condition for this result is that space and time be relative to a frame of reference. In other words, Einstein reconstructed space and time so that the velocity of light would be the same in all systems in accordance with the principle of relativity.

But how can one reconstruct space and time. Do not space and time have an intrinsic nature which we must apprehend? It is at this point that the operational theory of physical concepts becomes relevant. The theory of relativity was made possible by the recognition that physical concepts and laws refer to the numbers which are assigned by our operations. More specifically, the special theory of relativity starts from a more explicit consideration of the operations of measuring time and space.

Consider, for example, the theory of time. In the classical, absolutistic theory it was assumed as self-evident that there is a single time-system in which events have position. The relativistic criticism is based upon the fact that in order to assign numbers as the times of events one must have some physical process which serves as a clock. Thus the vibrations of the balance wheel of a watch define a time system. Assuming that the clock is provided with a pointer and scale, one can determine the time of an event in the immediate neighborhood of the clock by noting the reading coinciding with the hand simultaneously with the event. The definition of time at a place thus offers no difficulties. The problem becomes more difficult, however, when we attempt to define a time system throughout a space. We may do this by placing similar clocks at the different points at which we may wish to determine the time. The clocks at separated points, however, must be synchronized in order that the times of events which are determined by different clocks may be compared. The classical physicist did not recognize the assumptions made in comparing the times at different places. This was partly because he thought of these times as intrinsic properties of the events which were located in a time system. The relativistic criticism, however, is based upon the operational point of view; we must describe a method of synchronizing clocks.

The method which naturally suggests itself is signaling by electromagnetic waves, such as light. Suppose that two clocks are located at distant points A and B. Let a signal be sent from A to B, where it is reflected back to A. Let t_A be the time at which the signal leaves A and t_A' the time at which it returns. The clocks A and B may now be synchronized by the definition that the time of arrival of the signal at B is t_B such that

$$t_B = \frac{t_A + t_A'}{2}.$$

This definition implies that the velocity of light from A to B is the same as that from B to A. Another way of stating the definition is:

$$t_B = t_A + \frac{l}{c}$$

$$t_A' = t_B + \frac{l}{c} \cdot$$

From these it follows that

$$t_B = \frac{t_A + t_A'}{2} \cdot$$

The latter discussion shows that what is really done in this definition is to use the principle of the constancy of the velocity of light as the definition of the time required for the light signal to travel a certain distance. The principle of the constancy of the velocity of light thus becomes the basis for extending a time system throughout space. The principle is a definition of time.

Now in accordance with the principle of relativity we should employ the same method of synchronizing clocks in all permissible frames. The principle of the constancy of the velocity of light is to hold in all systems. Now since the velocity of light is finite it follows that the time system is relative to the frame of reference employed. Two separated events which are simultaneous in one system will not be simultaneous in a system moving with uniform rectilinear velocity with respect to the first. A simple example illustrates the relativity of simultaneity. Let us suppose that at the two ends of a moving train there are devices for sending light signals. Suppose that an observer on the ground is midway between the points on the earth which at the same instant with respect to the earth coincide with the endpoints of the train. Signals sent out at that instant reach the observer simultaneously. The method of synchronizing clocks is such that he judges that the signals were emitted simultaneously. The events were simultaneous to the observer on the ground. But the observer on the train, who judges himself to be midway between the two ends, will not receive the signals at the same time. Since he judges that the light has traveled equal distances he infers that the signals were not started simultaneously. The observer on the ground may explain this discrepancy by pointing out that the observer on the train moves towards one signal and away from the other.

By the principle of relativity, which does not allow us to select one system as absolutely fixed, the observer on the train may also judge two events to be simultaneous which are not simultaneous to the observer on the ground.

The relativity of time entrains the relativity of space. Suppose, for example, that we wish to measure the length of a rod. If the rod is at rest its length is measured by counting the number of times that the standard may be laid off on the rod. If the rod is in motion we must employ a different method. For example, we determine the points on the frame which simultaneously coincide with the endpoints of the rod which is moving with respect to the frame. We then measure the distance between the two points on the frame by the usual method for bodies at rest. The number obtained is the length of the moving rod. But the determination of the points on the frame which simultaneously coincide with the endpoints of the moving rod depends upon simultaneity, which is relative. Thus if a rod is set in motion it contracts with respect to the fixed frame, but retains the same length relative to a moving frame in which it is at rest. A figure which is a circle in a frame in which it is at rest is an ellipse in a frame with respect to which it is moving. Hence the spatial properties of bodies depend upon motion. Since these properties may be studied in a frame in which the bodies are at rest, as well as in a frame in which the bodies are in motion, space is relative to a frame or system of reference.

The quantitative formulation of the special theory is based upon the equations which express the relations between the spaces and times of frames in uniform motion with respect to each other.

Let x, y, z, t be the Cartesian coordinates and the time of an event in the frame K.

Let x', y', z', t' be the coordinates and the time of the same event in the frame K' which is moving with constant velocity v along the positive direction of the x axis.

At time $t=t'=0$ a light signal is emitted from the origins of K and K', which coincide at that instant.

Then the principle of the constancy of the velocity of light relative to K is expressed by

$$x^2 + y^2 + z^2 - c^2t^2 = 0.$$

By the principle of relativity, the same principle relative to K' is expressed by

$$(x')^2 + (y')^2 + (z')^2 - c^2(t')^2 = 0.$$

In order that both of these may hold we must have

$$x' = \beta(x - vt)$$
$$y' = y$$
$$z' = z$$
$$t' = \beta\left(t - \frac{vx}{c^2}\right)$$

where

$$\beta = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}.$$

These equations express the Lorentz transformation.

The special theory of relativity furnished the basis for the concept of a four-dimensional space-time. This means that events are specified by four numbers, three for space and one for time.

In ordinary space the distance between two points $(x_1\ y_1\ z_1)$ and $(x_2\ y_2\ z_2)$ is given by

$$s^2 = (x_2 - x_1)^2 + (y_2 - y_1)^2 + (z_2 - z_1)^2.$$

In space-time, events are specified by coordinates $x\ y\ z\ t$. The space-time interval between two events $(x_1\ y_1\ z_1\ t_1)$ and $(x_2\ y_2\ z_2\ t_2)$ is given by

$$s^2 = (x_2 - x_1)^2 + (y_2 - y_1)^2 + (z_2 - z_1)^2 - c^2(t_2 - t_1)^2.$$

This formula is analogous to the formula for distance in ordinary space. Hence we conceive of a space-time manifold of events. Since the time occurs with a minus sign in the formula time is distinguished from space. (An alternative formulation uses an imaginary variable $l = ict$.) We say that according to the special theory of relativity space-time is pseudo-Euclidean.

By way of summary one may say that in the special theory of relativity Einstein modified the theory of space and time so that the principle of relativity of uniform motion is extended to electromagnetic theory.

The special theory of relativity is so-called because it is valid only for a selected set of systems of reference. The permissible systems are said to be at rest or in uniform motion. Accelerated

frames, for example, rotating frames, are not allowable in the special theory or in classical mechanics. Thus the laws of mechanics or of electromagnetism do not hold in an accelerated car, or in an airplane looping the loop. In the general theory of relativity Einstein has formulated the laws of physics so that they will hold in all frames of reference.

The starting point for the general theory is the well established fact that all bodies have the same acceleration in a gravitational field. For the gravitational field of the earth this was established by Galileo when he dropped a heavy and a light body from the tower of Pisa and found that they reached the ground in the same time. This fact about gravitational fields is the basis of the *principle* of *equivalence*.

Suppose that relative to a certain frame of reference there is no gravitational field. Then, if a body is not acted upon by any other force, the body remains in its state of rest or of uniform motion. If the frame of reference is now accelerated the bodies which were previously at rest or in uniform motion will be accelerated with respect to the frame. All bodies will receive the same acceleration as if they were in a gravitational field. Thus the acceleration of a frame of reference produces the same effect upon phenomena as a gravitational field. This is the principle of equivalence.

The principle of equivalence makes possible a general principle of relativity. Any frame of reference may be employed, but relative to some frames there will be gravitational fields.

The general theory of relativity thus leads to a theory of gravitation.

The relativity theory of gravitation is that gravitation is a manifestation of the curvature of space-time.

The concept of curvature may be explained for surfaces. We distinguish between a plane and a curved surface, like the surface of a sphere. In the plane there are Euclidean straight lines; in the curved surface there are geodesic lines which are the shortest lines between two points. On a spherical surface the geodesic lines are great circles. The sum of the angles of a plane triangle is two right angles; the sum of the angles of a spherical triangle is greater than two right angles. It is possible to construct a Cartesian coordinate system in the plane, so that if (x, y) and $(x+dx, y+dy)$ are two points the square of the distance between them ds is given by

$$ds^2 = dx^2 + dy^2.$$

On a sphere it is impossible to construct a Cartesian coordinate system. One may, however, introduce Gaussian coordinates u, v such that the distance between (u, v) and $(u+du, v+dv)$ is given by $ds^2 = g_{11}\, du^2 + 2g_{12}\, du dv + g_{22}\, dv^2$. The curvature of the surface can be described in terms of the coefficients g_{11} etc. which differ from the Euclidean values. The g's describe the relations between the standard of length and the sides of a coordinate mesh.

The foregoing considerations may be extended to three dimensions and to four-dimensional space-time.

The relativity theory of gravitation may now be stated as follows: In a region free from matter the special theory of relativity holds. This means that space-time is described by

$$ds^2 = dx^2 + dy^2 + dz^2 - c^2dt^2.$$

In the vicinity of matter space-time is curved. We introduce coordinates $x_1\, x_2\, x_3\, x_4$. Then space-time is described by

$$ds^2 = g_{11}dx_1^2 + g_{22}dx_2^2 + \cdots.$$

The g's describe the geometry of the space-time, and also the gravitational field. The law of gravitation describes the dependence of the structure of space-time upon matter. The law of motion of a particle is that it describes a geodesic in curved space-time. The law of gravitation and the law of motion are expressed in a form which is unchanged by any change of coordinates. Thus the laws of motion are the same for all frames of reference. Thus a general principle of relativity is realized.

In the Newtonian theory a force of gravitation was introduced in order to explain why the planets do not move in straight lines. In the relativity theory the concept of curvature replaces that of force. What appears to be motion under forces from the Euclidean point of view is motion along a geodesic in curved space-time.

The general theory of relativity gave rise to cosmological speculations about the structure of the universe. This problem is yet unsolved. At present much interest has been manifested in the concept of an expanding universe.

The general theory of relativity was restricted to gravitation. The attempt has been made to extend the geometry of space-time so as to include electromagnetism. This is the subject-matter of unitary field theory. This problem is still un-

solved. Einstein has been proposing a new solution about once a year.

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A. Einstein. *The Theory of Relativity*, Methuen.
H. Thirring. *The Ideas of Einstein's Theory*, Methuen.
A. Eddington. *Space, Time and Gravitation*, Cambridge, University Press.
M. Born. *Einstein's Theory of Relativity*, Methuen.
V. Lenzen. *The Nature of Physical Theory*, Wiley and Sons.

COSMIC RAYS AND THE "DANCE OF ENERGY"

By SUE AVIS BLAKE
Bryn Mawr College, Bryn Mawr, Pennsylvania

Since my article, "The Dance of Energy" in the October issue of SCHOOL SCIENCE AND MATHEMATICS went to press, results of recent investigations by Dr. A. H. Compton and by workers of the Bartol Research Foundation of the Franklin Institute, Swarthmore, Pa., have appeared in print. These results indicate that cosmic rays pierce the Earth's atmosphere more frequently from the magnetic north and south than from east and west, thus leading us to suspect that they are particles capable of being deflected by a magnetic field rather than radiation. It is not yet perhaps an established fact that they are particles, and I heard Dr. Swann, Director of the Bartol Foundation, recently say that we have no data about particles so highly energized as cosmic rays would be and do not know how different they would then be from radiation!

BETTERING HUMAN VOICE AND EAR

A mechanical speaker that talks better than the human mechanism and an artificial ear that hears more effectively than man's auditory organ, for testing telephone transmitters and receivers, are shown at work in the Bell Telephone Laboratories. This newly developed apparatus replaces the human voice and ear in research devoted to the production of telephones that will transmit speech more effectively.

An electrical phonograph is the source of the voice in the artificial speaker and a number of electrical circuits assure its natural qualities. The artificial mouth is so carefully built that its speech is distorted by objects in front of it just as sounds from a human mouth are broken up, it is explained by A. H. Inglis, C. H. G. Gray, and R. T. Jenkins, engineers.

Not only does the artificial speech check within a few per cent by diagrammatic analysis with the original human product, the engineers state, but it also sounds natural. An important advantage of the mechanical mouth and ear is that they reproduce exactly the same sound and hear with precisely the same sensitiveness and distinction every time they are used. Their human counterparts vary with mood and physical condition of the person talking or listening.

VERBATIM RECORD OF A RECITATION IN GEOMETRY

By Joseph A. Nyberg
Hyde Park High School, Chicago

Just what does happen in a classroom? In order to answer this question as exactly as possible a stenographer was hired to visit some classes and record everything that was said by both teacher and pupil. The stenographer also kept a record of the lapse of time so as to show how many minutes were devoted to each part of the work. Verbatim records were thus made of classes in geometry, algebra, and arithmetic in the seventh and eighth grades. The stenographer had had three years of mathematics in high school, had attended college, and was familiar with mathematical terms.

Teachers who have read the records are invariably surprised for one reason or another. Hence a few of them will be published.

Students in schools of education may also be interested in these records. I remember that as an undergraduate I was often required to write lengthy papers on how I should present certain ideas in a class, what the teacher should say, what response might be expected, how the next day's assignment should be made, how much time should be devoted to it, which principles of pedagogy I was illustrating, and so forth. The stenographer's notes will show how and if the theories are applied.

The record presented this month was taken in a class in Geometry on Monday of the fifth week of school. Evidently the work on the preceding Friday had dealt with the base angles of an isosceles triangle. There were 38 pupils. The pupils are named A, B, etc., for convenience in the record. Theorem 4, assigned for the next day's work, proves triangles congruent if the corresponding sides are equal.

* * *

T. Has everyone their homework here? (pointing to the pile of papers in one corner of the desk). Get the habit of leaving it here at the desk when you come in so that we wont have any interruptions. We'll have two people put the figures on the board and, while they are getting the figures ready, we can talk about some other exercise. Miss A, exercise 1. Construct the figure carefully and don't make it too small. Miss B, exercise 2. When

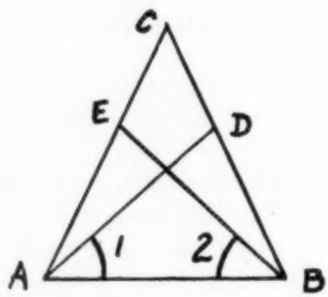
you finish the figure it will look exactly like the figure for exercise 1, but the construction is different. Everybody else ready with paper, ruler, compass?

(2 minutes)

T. Start exercise 3. The figure in the book looks equilateral, but it is not meant to be. The hypothesis doesn't say so.

P. Exercise 3?

T. Three. First of all draw a horizontal line. Mark it AB. Draw it about 2 or $2\frac{1}{2}$ inches. I wouldn't put it in the middle of the paper. Put it either a little to the right or a little to the left in order to have room to write the hypothesis and what you are to prove. According to the hypothesis, $AC = BC$.



The teacher, walking around the room, gave the following instructions to different pupils: That triangle will look equilateral. Better make that line a trifle longer. You ought to have either a low flat triangle or a tall slim one. That triangle looks equilateral. Change that radius. It takes a little practise before you can do it correctly without starting over a few times. That triangle looks equilateral.

(7 minutes)

T. (Continuing to walk around the room) The hypothesis says $\angle 1 = \angle 2$. When two angles are equal, the first can be made any size, but the second must be equal to it. Now draw angle 2. (To one pupil) That's correct. The end of that line we call D. (To the class) Through B we must draw a line so that angle 2 will equal angle 1. In other words, you copy angle 1 at B. If you don't know how to copy an angle, you will have to look it up in the book. (To one pupil) You haven't a compass? (To another pupil) What exercise are you doing? That is the homework. We are now working exercise 3. (To the class) The second side of angle 2 is the line BE. Alongside of your figure

write the hypothesis. The hypothesis is, of course, stated in the book. But you should know what the hypothesis is without looking in the book because the hypothesis tells how we drew the figure. Miss C, read the hypothesis as you wrote it on your paper.

P. Hypothesis. $AC = BC$ and $\angle 1 = \angle 2$.

T. Everyone have that? You also write down, just below the hypothesis, what you are to prove. Tell us what we are to prove in this exercise, Miss D?

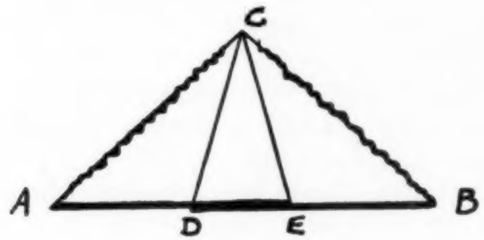
P. $AE = BD$.

T. Correct. Now you should all have something like this (Holding up the paper of one pupil). The figure. The hypothesis. What you are to prove. Below all this, we'll write the proof. Just put aside this work, and we'll come back to it later.

(12 minutes)

T. Look at the figure on the board. Exercise 1. $AC = BC$ and $AE = BD$. We'll mark the lines AC and BC (Drawing a wavy line over AC and BC). Also the lines AE and BD (Making these lines about an inch wide by placing the chalk flat on the board). Use various kinds of markings. Miss D, come to the board and prove $CD = CE$.

P. (At the board) $AC = BD$, no, BC.



T. Wait a minute. (To the class) What do you think I am about to say?

P. You want to know what triangles she is going to talk about?

T. Yes. If the figure involves a lot of triangles, we must know which ones she is thinking of.

P. Well, consider triangles BDC and ACE.

T. Use a ruler instead of a piece of chalk to point with.

P. $AC = BC$ by hypothesis. $AE = BD$ by hypothesis. Triangle ABC is isosceles because two lines, AC and BC, are equal.

$\angle EAC$ and $\angle DBC$ are base angles. These angles are equal because the base angles of an isosceles triangle are equal.

T. Continue, Mr. E.

P. I wasn't here Friday.

T. Mr. F.

P. Well, she mentioned that triangle ABC is isosceles. $\angle A = \angle B$.

T. Why are those angles equal?

Pause. The pupil could not answer.

T. I suspect I shall see you come in for some help this afternoon. Continue, Miss G.

P. $\angle A = \angle B$ because base angles of an isosceles triangle are equal.

T. Continue, Mr. H.

P. $CE = DE$ because corresponding parts of congruent triangles are equal.

T. Which two triangles have you proved congruent?

P. No. But two sides are equal.

T. That is enough to prove two triangles congruent, is it?

P. No. (Pupil walks back to his seat.)

T. We'll start all over again. What triangles did we decide to study? Mr. I.

P. (At the board) These two.

T. Don't say "These two." The triangles can be named.

P. Triangle CAE and CAD.

T. Point to them slowly.

P. (Pointing) Triangle $C—A—E$ and $C—A—D$.

T. Do you think you can prove those triangles congruent?

P. Triangles CAE and CBD.

T. That's better. Shade the triangles with some chalk. (Pupil does so.)

P. $AC = BC$ by hypothesis. $\angle CAD$ or $\angle CAE = \angle CBD$ because base angles of an isosceles triangle are equal.

T. But you didn't tell us that there was an isosceles triangle in the figure. Don't repeat it now. Go ahead.

P. $AE = BD$.

T. Why are they equal, Miss J?

P. By hypothesis.

T. Now we are as far along as we were last time.

P. (At the board) Triangle ACE is congruent to triangle CBD because side angle side equals side angle side.

T. Point to the sides and angles you have in mind.

The class laughs as the pupil points incorrectly to various parts.

T. When you say "angle" you should be pointing to an angle, not to a side. The pupil then does the pointing correctly.

T. That's far enough. Continue, Mr. K.

P. Then $CD = CE$ because corresponding sides of congruent triangles are equal.

T. Can you prove $CD = CE$ by using some other triangles? Miss L?

P. Yes. Triangles CDB and ACE.

T. Which triangles did we use in the work we just finished?

P. Triangles BDC and ACE.

T. Is your choice any different?

P. No-oh.

Another pupil. I used triangles CAD and CBE.

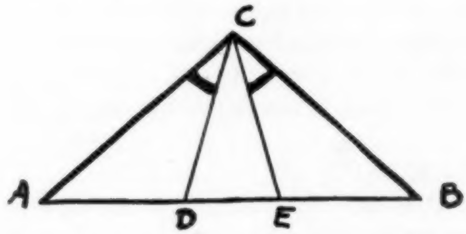
T. Can you tell us briefly how you proved the triangles congruent?

P. $AC = BC$; $\angle A = \angle B$; and I can get $AD = EB$ by subtracting DB and AE from AB. Then side angle side equals side angle side.

T. That's correct and just as good.

(21 minutes)

T. Exercise 2 next. Notice that the figures look alike but the hypothesis is different. Go to the board and mark the figure so as to show the parts that are equal by hypothesis, Mr. M. (Pupil does so.) Make AC and BC broad lines. Mark $\angle DCA$ by a broad arc. Start the proof, Miss N. Don't forget to tell us what triangles you are considering.



P. Consider triangles CAE and CBD. $\angle DCA = \angle ECB$ by hypothesis. CD equals . . .

T. You are to prove something about CD.

P. The triangle ACB is an isosceles triangle because $AC = BC$. Therefore $\angle A = \angle B$. $\angle ACD = \angle BCE$ by hypothesis. Triangle

ACD is congruent to triangle *BCE* by angle side angle equals angle side angle. $CD = CE$ because corresponding parts of congruent triangles are equal. (This pupil recited very slowly.)

T. Anybody use some other triangles? (Pause) Any questions?

(30 minutes)

T. The other exercise, number 3, that we started, we'll have for homework. The other part of the homework is Theorem 4. Look at it. Notice that it is almost proved completely in the book. After you have studied it and think you know all about it, get out some paper, construct the figure, write down the hypothesis and what you are to prove. Then close the book and see if you can write the proof. If you can't write it, open the book and see what you have forgotten. Close the book and try it again. Do this until you can prove the theorem.

(32 minutes)

T. Let's try another problem. Mr. O and Mr. P and Miss Q work at the board. The rest of us will do the same work on paper. Draw a line about 3 inches long—at the board about 2 feet long. Call the left hand end, *A;* the right hand end, *B*. Listen, now, to the directions, and see if you can carry them out without further instructions. Construct two isosceles triangles, both having *AB* for the base. Make one triangle above *AB*, and the other below *AB*. Don't have the two triangles congruent; make one larger than the other.

The teacher then walked around the room giving instruction to individuals: That line will be of no use. That triangle looks equilateral. You're using the wrong center for that arc. The second triangle should hang below *AB*.

T. (To the class) Call the top point *C* and the lower point *D*. (To a pupil) We would not write $\angle 1 = \angle 2$ as part of the hypothesis. (To the class) What is the hypothesis for this figure, Miss R?

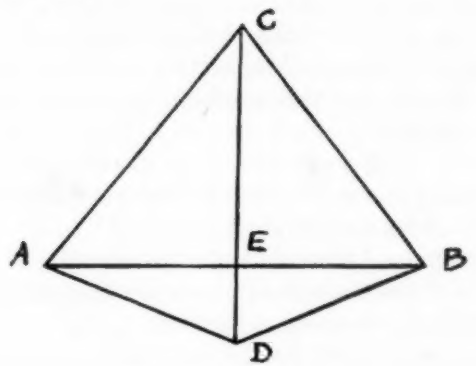
P. $AC = BC, AD = BD$.

T. Correct. It is true that there are certain equal angles in the figure, but we do not write that in the hypothesis. Don't write in the hypothesis everything that is true in the figure. Now draw the line *CD*. The intersection of *AB* and *CD* call *E*. And write: Prove: $\angle ACE = \angle BCE$. How do we prove angles equal, Miss S?

P. By congruent triangles.

T. What are some of the ways of proving triangles congruent, Mr. T?

P. Side angle side equal side angle side. Angle side angle equal angle side angle.



T. Mark in your figure the parts that are equal by hypothesis. (Pause)

According to the way in which you just marked your figure, which triangles can be proved congruent, Miss U?

P. Triangles ACD and BCD.

T. What method will you use, Miss V?

P. Side angle side equal side angle side.

T. Why do we use that method, Miss W?

P. Because I know it will work.

T. But how do you know it will work?

P. Why, I looked at the picture.

T. What are the two angles that you must show are equal?

P. Angles CAD and CBD.

T. How can you get these angles equal when the hypothesis says nothing about them, Mr. X?

P. Use base angles of an isosceles triangle.

T. But is $\angle CAD$ the base angle of an isosceles triangle?

P. No. But $\angle CAB$ is; and $\angle CBA$ is, and $\angle DBA$ is, and . . .

T. Not so fast. Start again.

P. $\angle CAB = \angle CBA$. Base angles of an isosceles triangle are equal. $\angle DAB = \angle DBA$. Base angles of an isosceles triangle are equal. Then if equal angles are added to . . .

(The bell rang for the end of the period.)

(40 minutes)

* * *

The class in pedagogy may now discuss these questions:

1. What per cent of the pupils took part in the recitation?

2. Had Miss N prepared her homework, or did she work out a proof while she was reciting?

3. Was there any particular reason why the teacher chose the exercise that was studied during the last 8 minutes?

4. The teacher suggested a certain method for studying Theorem 4. Would not this method encourage the pupil to memorize the proof?

5. How could such memorizing be discouraged? Was anything done during the recitation to discourage the memorizing?

6. Why is exercise 2 easier than exercise 1?

7. Why is exercise 3 more difficult than exercise 2?

8. How would you answer the question that the teacher put to Miss W: Why do we use that method?

9. How do you account for the fact that the pupils asked no questions? Does the absence of questions show good or poor teaching on the part of the teacher.

10. How do you think the next day's recitation will be conducted?

SIGNIFICANT FACTS ABOUT AMERICAN EDUCATION

Twenty-three of every 1000 adult Americans are college graduates. One hundred twenty-five of every 1000 are high-school graduates. The chances of a boy or girl going to high school, which were only 1 in 25 in 1890 are now 1 in 2. The chances of a boy or girl going to college, which were only 1 in 33 in 1900 are now 1 in 6. One of every 4 Americans attended some kind of school during the past year. Of every 1000 pupils in fifth grade, 610 enter high school, 260 graduate from high school, 160 enter college and 50 graduate from college.

Ten cents per day paid by every person of voting age in the United States would pay the entire bill for public education: Per year for each child: Elementary, current expense, $67.82; high school, $144.03; college and university, $500. Costs per school day per child in public elementary school: 39 cents; in high school: 80.9 cents. Costs per hour per child in public elementary school, 7.8 cents; in high school, 16 cents. Costs per hour per class (average of 39 elementary pupils) $3.04; (average of 25 high-school pupils) $4. Of these costs 75 per cent is for providing instruction by trained teachers and supervisors. The above facts have been brought together largely from statistics collected on a nation-wide scale by the Office of Education in Washington, D.C.

SCIENCE LIBRARY FOR ELEMENTARY SCHOOLS

ELLIS C. PERSING
Western Reserve University, Cleveland, Ohio
Editor Science and Invention School Service Magazine

The reaction of teachers to the first book list[1] has encouraged the writer in preparing the second one.

Books for pupils are placed under one of the main headings in the field of science so that it will not be difficult to select the newest materials for a particular phase of natural science on the elementary school level.

Teachers books are classified in a similar manner, making it possible for one to find readily background reading materials to enrich the science curriculum.

The brief comment given for each book will indicate its place in the school library. Textbooks are mentioned, but the emphasis is placed on the titles that will supplement the regular classroom work. The titles suggest a means by which pupils will have opportunity to explore into the fields of science. The content is fairly representative of the fields of science and offers a wealth of material for enriching the pupils' experiences.

STUDENTS' REFERENCES

ELEMENTARY SCHOOL

ANIMALS

Du Puy, William A. *Wonders of the Animal World*, Heath, 1930. (A supplementary reader for upper grades.) $.88

Eifrig, C. W. *Our Great Outdoors—Mammals*, Rand, 1930. (For the upper grades.) $1.28

Gauss, Marianne. *Book of the Woods*, Laidlaw, 1931. (Animal stories of the Estes Park region. Factual reading for upper grades.) $0.00

Johnson, Martin. *Congorilla*, Brewer, 1932. (Fascinating story of Martin Johnson's experiences as a big game photographer in Africa.) $3.50

Kearton, Cherry. *In the Land of the Lion*, McBride, 1930. (An account of the animal life of Africa with illustrations by the author.) $2.50

Peterson, Alvin M. *Powderpuff*, Bruce, 1930. (A supplementary reader for the lower grades.) $.72

Walker, E. B., and Mook, C. C. *Tales of the First Animals*, Farrar, 1930. (The story of the development of the prehistoric world. For lower grades.) $1.50

AVIATION

Dobias, Frank. *The Picture Book of Flying*, Macmillan, 1928. (For primary grades. Attractive illustrations.) $2.00

Engleman, F. E., and Salmon, J. *Airways*, Heath, 1931. (Supplementary reader for upper grades.) $.80

[1] This Journal, vol. XXXII no. 1.

Harper, Harry. *The Evolution of the Flying Machine*, McKay, 1930. (Evolution of the balloon, the airship, and the airplane as told for the young student and lay reader. Excellent illustrations.) $5.00

Hylander, C. J. *Cruisers of the Air*, Macmillan, 1931. (Factual material for upper grades.) $2.50

Iseman, J. W., and Taylor, S. *The Book of Airplanes*, Oxford, 1929. ("A boy's history of flying.") $1.00

McNamara, John F. *Playing Airplane*, Macmillan 1930. (Supplementary reader for lower grades.) $2.50

Mooney, James E. *Air Travel*, Scribner, 1930. (A supplementary reader for the upper grades.) $1.00

Ross, Malcolm. *Sailing the Skies*, Macmillan, 1931. (An introduction to a new and popular sport—gliding and soaring.) $2.50

Thomson, Jay E. *Aviation Stories*, Longmans, 1929. (A supplementary reader for the upper grades.) $1.00

Biography

Cottler, Joseph, and Jaffe, Haym. *Heroes of Science*, Little, 1932. (Stories of noted scientists. Upper grades.) $.90

Speed, James. *Ten Outdoor Men*, Heath, 1929. (A supplementary reader for upper grades.) $.72

Birds

Ashbrook, Frank G. *The Blue Book of Birds of America*, Whitman, 1931. $.10

Ashbrook, Frank G. *The Green Book of Birds of America*, Whitman, 1931. $.10

Ashbrook, Frank G. *The Red Book of Birds of America*, Whitman, 1931. $.10

Morris, Mae N. *Stay-At-Home Birds*, Crowell, 1929. (A supplementary reader for the primary grades.) $1.50

Stoddart, Julia T. *Strange Birds at the Zoo*, Crowell, 1929. (A supplementary reader for the primary grades.) $1.50

Discovery, Invention and Exploration

Gable, J. Harris. *Boys' Book of Exploration*, Dutton, 1930. (Stories of the early explorers. Illustrated with maps and rare old prints.) $3.50

Gould, Laurence. *Cold*, Brewer, 1931. (A fascinating account of the author's experiences with the Byrd Antarctic expedition.) $3.50

Earth

Goldsmith, Milton. *Old Mother Earth and Her Family*, Sully, 1930. (Physical features, the countries, and the people of the earth are presented in narrative form. For the upper grades.) $2.00

Jeffreys, H. *The Future of the Earth*, Norton, 1929. (A handy pocket volume.) $1.00

Elementary School

Bailey, Marion E. *Boys' and Girls' Ask-At-Home Questions*, Stokes, 1915. (Some of the questions of boys and girls answered.) $2.00

Experiments

Lippy, John D. (Jr.). *Chemical Magic*, Sully, 1930. (Chemistry is presented here not as a science but for amusement and pastime.) $2.00

McKay, Herbert. *Easy Experiments in Elementary Science*, Oxford, 1929. (An attractive list of experiments.) $.50

FURS

Lange, D. *On the Fur Trail*, Newson, 1931. (A supplementary reader for upper grades.) $.72

GENERAL REFERENCE

Chalfant, W. A. *Death Valley*, Stanford, 1930. (Facts about Death Valley for the layman. Geography, climate, plant life, animal life, and geology are the topics presented.) $3.50

GEOGRAPHY

Hartman, Gertrude. *The World We Live In*, Macmillan, 1931. (The story of man from earliest days to the age of machines. Attractive and helpful illustrations.) $5.00

Huntington, Benson, McMurry. *Living Geography—Book 1*, Macmillan, 1932. (A text in geography for the lower grades.) $1.20

Huntington, Benson, McMurry. *Living Geography—Book 2*, Macmillan, 1932. (A text in geography for the upper grades.) $1.60

Mitchell, Lucy S. *North America*, Macmillan, 1931. (The story of life in North America told in story and pictures.) $3.50

Stull, De Forest, and Hatch, R. W. *Our World Today*, Allyn, 1931. (For the upper grades.) $1.50

HEAT

Hough, Walter. *The Story of Fire*, Doubleday, 1931. (Supplementary reading for upper grades.) $2.00

HEAVENLY BODIES

Kenly, Julie C. *Children of a Star*, Appleton, 1932. (Facts which everyone wants to know about birds, beasts, fishes and insects are presented.) $2.50

McKay, Herbert. *First Steps in Science—Book 6: The Sun and the Moon*, Oxford, 1929. (Science booklet for the primary grades. Attractive illustrations.) $.40

LIGHT

McKay, Herbert. *First Steps in Science—Book 3: Candles and Lamps*, Oxford, 1929. (A science booklet for the primary grades.) $.40

LOOKING-GLASSES

McKay, Herbert. *First Steps in Science—Book 5: Looking-Glasses*, Oxford, 1929. (A science booklet for the primary grades. Attractive illustrations.) $.40

NATURE STUDY

Patton, Donald. *Nature Study for Beginners*, Oxford, 1929. (Factual material on plant and animal life.) $.85

PETS

Aldin, Cecil. *The Mongrel Puppy Book*, Oxford. (A supplementary reader for the lower grades.) $1.25

Bianco, Margery W. *All About Pets*, Macmillan, 1930. (Factual material for upper grades.) $2.00

PLANTS

Du Puy, William A. *Wonders of the Plant World*, Heath, 1931. (A supplementary reader for upper grades.) $.88

Seward, A. C. *Plants, What They Are and What They Do,* Macmillan, 1932. (The fundamental principles of plant life are illustrated in non-technical terms.) $1.50

PSYCHOLOGY

Downey, June E. *The Kingdom of the Mind,* Macmillan, 1927. (Many of our young people's questions about themselves are answered in this book.) $2.00

RAIN

McKay, Herbert. *First Steps in Science—Book 1: Rain in the Garden,* Oxford, 1929. (Science booklet for the primary grades. Attractive illustrations.) $.40

RECREATION

Handiwork

Taylor, Mary P. *How to Make Hooked Rugs,* McKay, 1930. (Excellent illustrations and suggestions for one profitable way to spend the leisure time.) $2.00

Sports & Games

Duff, James. *Bows and Arrows,* Macmillan, 1927. (A practical book for persons interested in archery.) $2.00

McGuire, Harry. *Tales of Rod and Gun,* Macmillan, 1931. (A collection of hunting and fishing stories. A book of thrilling adventure.) $2.50

Stamp Collecting

Mac Peek, Walter. *Stories Stamps Tell,* Mac Peek, 1931. (A system of keeping in stamps their records is suggested.) $.20

SCIENCE READERS AND TEXTS

Conway-Kauffman-Lancelot. *Nature in Agriculture,* Webb, 1928. (A text for the upper grades.) $1.20

Craig, G. S., and Baldwin, S. E. *Our Wide, Wide World,* Ginn, 1932. (For the upper grades.) $.76

Craig, G. S., and Baldwin, S. E. *Out-of-Doors,* Ginn, 1932. (For primary grades.) $.76

Craig, G. S., and Hurley, B. D. *The Earth and Living Things,* Ginn, 1932. (For upper grades.) $.76

Edwards, P. G., and Sherman, J. W. *The Nature Activity Readers,* Little, 1931. (Science readers for primary grades.) Book 1, $.72; Book 2, $.76

Eifrig, C. W. G. *Our Great Outdoors—Reptiles, Amphibians, and Fishes,* Rand, 1930. (For upper grades.) $1.28

Holtz, G. M., and Hall, J. *Elementary Science—Book 3,* Mentzer, 1930. (For primary grades.) $.60

Mann, P. B., and Hastings, G. T. *Our of Doors,* Holt, 1932. (A handbook for young people to use in camp or on hikes.) $1.60

Patch, Edith, and Howe, Harrison. *Hunting,* Macmillan, 1932. (For primary grades.) $.84

Patch, E. M., and Howe, H. E. *Outdoor Visits,* Macmillan, 1932. (For lower grades.) $.84

Reed, W. Maxwell. *The Earth for Sam,* Harcourt, 1929. (The story of the earth written for nine-year-old children. The 250 photographs aid in telling the story. For lower grades.) $3.50

Teeters and Heising. *Early Journeys in Science*, Lippincott, 1931. (For primary grades.) Book 1,$.68; Book 2, $.72.

Teeters and Heising. *Early Journeys in Science, Book 3*, Lippincott, 1931. (For upper grades.) $.80

Ships

Diggle, Captain E. G. *The Romance of a Modern Liner*, Oxford. (A fascinating story of the modern liner, profusely illustrated.) $2.50

Gimmage, Peter. *The Picture Book of Ships*, Macmillan, 1932. (For primary grades.) $2.00

Sky Studies

Fontany, Elena. *Other Worlds Than This*, Rockwell, 1930. (A science reader for upper grades.) $1.25

Trafton and Others. *The Sky Book*, Slingerland. (A looseleaf notebook.) $.75

Sound and Noise

McKay, Herbert. *First Steps in Science—Book 2: Sound and Noise*, Oxford, 1929. (Science booklet for the primary grades. Attractive illustrations.) $.40

Supplementary Readers

Bronson, Wilfrid S. *Fingerfins*, Macmillan, 1930. (For the lower grades. Delightful and helpful illustrations.) $2.00

Bronson, Wilfrid S. *Paddlewings*, Macmillan, 1931. (For the lower grades.) $2.00

Danford, Harry E. *Ohio Valley Pioneers*, Rand, 1931. (For the upper grades.) $1.00

Fuller, Raymond T. *Along the Brook*, Day, 1931. (A handy and accurate guide for adventuring along the brook. Attractive and helpful illustrations. $1.50

Jamison, Louise. *Mother Nature's Little People*, Owen, 1930. (For lower grades.) $.72

Law, Frederick H. *Our Class Visits South America*, Scribner, 1930. (For upper grades.) $1.00

Patch, Edith M. *Holiday Hill*, Macmillan, 1931. (For lower grades.) $2.00

Patch, Edith M. *Holiday Meadow*, Macmillan, 1930. (For upper grades. Excellent illustrations.) $2.00

Read, Helen. *Grandfather's Farm*, Scribner, 1928. (For lower grades. Beautifully illustrated.) $.60

Read, Helen S. *Jip and the Fireman*, Scribner, 1929. (For lower grades. Beautifully illustrated.) $.60

Read, Helen S. *Mary and the Policeman*, Scribner, 1929. (Beautifully illustrated. For the lower grades.) $.60

Read, Helen S. *Mr. Brown's Grocery Store*, Scribner, 1929. (For the lower grades. Beautifully illustrated.) $.60

Toys and Other Machines

Bock, George E. *What Makes the Wheels Go 'Round*, Macmillan, 1931. (A supplementary reader for the upper grades. Beautifully illustrated.) $2.50

Jones, Wilfred. *How the Derrick Works*, Macmillan, 1930. (For the upper grades.) $2.00

Kunou, C. A. *Easy-To-Make Toys*, Bruce, 1928. (Interesting toys to make.) $1.44

Wright, Harry B. *Toys Every Child Can Make*, Bruce, 1927. (Interesting toys to make.) $1.60

TRANSPORTATION AND LOCOMOTIVES

Lent, Henry B. *Clear Track Ahead!*, Macmillan, 1932. (For upper grades.) $2.00

WIND

McKay, Herbert. *First Steps in Science—Book 4: The Air and the Wind*, Oxford, 1929. (Science booklet for the primary grades. Attractive illustrations.) $.40

WORKBOOKS

White, M. L., and Hanthorn, A. *Workbook for Boys and Girls at School*, American, 1931. $.32

White, M. L., and Hanthorn, A. *Workbook for Boys and Girls at Work*, American, 1931. $.32

White, M. L., and Hanthorn, A. *Workbook for Interesting Things to Know*, American, 1931. $.32

White, M. L., and Hanthorn, A. *Workbook for Our Friends at Home and School*, American, 1931. $.32

White, M. L., and Hanthorn, A. *Workbook for Stories of Animals and Other Stories*, American, 1931. $.32

GEOGRAPHY

Stull, De Forest, and Raisz, Erwin J. *Home Geography Activities Book*, Nystrom, 1931. $.50

JUNIOR AND SENIOR HIGH SCHOOL

ANIMALS

Barrows, William M. *Science of Animal Life*, World, 1927. (A textbook.) $1.76

AVIATION

Harney, L. B., and Spaulding, R. H. *The Skycraft Book*, Heath, 1932. (A reader for grades 6–12.) $1.08

Kuns, Ray F. *Aviation Engines*, American Technical Society, 1931. (A practical treatise for students and persons especially interested in aviation engines.) $2.00

Studley, Lieut. Barrett. *Learning to Fly for the Navy*, Macmillan, 1931. (Clear directions for flying both sea and land planes. Well illustrated with photographs.) $2.00

BIOLOGY

Needham, J. G., and Needham, P. R. *A Guide to the Study of Fresh-water Biology*, Thomas, 1930. $1.00

Nelson, George E. *The Introductory Biological Sciences in the Liberal Arts College*, Columbia U., 1931. $1.50

BUILDING

Anonymous. *Light Frame House Construction*, Federal Board for Vocational Education, 1930. (Technical information for the apprentice and the journeyman carpenters.) $.40

Chemistry

Biddle, Harry C. *Chemistry for Nurses*, Davis, 1931. (A handy source book for teachers and students.) $2.75

Collins, A. Frederick. *How to Understand Chemistry*, Appleton, 1932. (The wonders of modern chemistry are presented in readable form.) $2.00

Jaffe, Bernard. *Chemical Calculations*, World, 1927. (A textbook in chemistry.) $1.28

General Science

Meister, Morris. *Energy and Power*, Scribner, 1930. (A textbook for junior high school.) $1.08

Meister, Morris. *Heat and Health*, Scribner, 1931. (A textbook for junior high school.) $1.08

Meister, Morris. *Magnetism and Electricity*, Scribner, 1930. (A textbook for junior high school.) $1.00

Meister, Morris. *Water and Air*, Scribner, 1930. (A textbook for junior high school.) $1.08

Pulvermacher, W. D., and Vosburgh, C. H. *General Science for Reviews*, Globe, 1929. $.67

Watkins, Ralph, and Bedell, Ralph. *Learning & Test Activities in General Science*, Macmillan, 1931. $.60

Health

Andress, J. M., and Brown, M. A. *Experiments in Health*, Ginn, 1929. (A laboratory manual.) $.48

Corwin, M. J., and Corwin, W. *The Science of Human Living*, Harr, 1931. (Here is a health book for the junior high school.) $1.68

Downing, Elliot T. *Science in the Service of Health*, Longmans, 1930. (The principles of science as well as the historical and biographical material are included in this book.) $2.00

Radio

American Radio Relay League. *The Radio Amateur's Handbook*, The American Radio Relay League, 1932. (A wealth of information for the amateur.) $1.00

Recreation

Sports and Games

Stone, Herbert L. *The America's Cup Races*, Macmillan, 1930. (The story of eighty years of racing for the America's cup.) $3.50

Textbooks

Agriculture

Plumb, Charles S. *A Study of Farm Animals*, Webb, 1930. (A high school text on agriculture.) $2.00

Biology

Hunter, George W. *Problems in Biology*, American, 1931. $1.76

Meier, W. H. D., and Meier, Lois. *Essentials of Biology*, Ginn, 1931. $1.68

Pieper, Beauchamp, and Frank. *Everyday Problems in Biology*, Scott, 1932. $1.60

Smallwood, Reveley and Bailey, *New General Biology*, Allyn, 1930.

Chemistry

Fletcher, G., and Smith, H., and Harrow, B. *Beginning Chemistry*, American, 1929. $1.60

Brownlee-Fuller-Hancock-Sohon-Whitsit. *First Principles of Chemistry*, Allyn, 1931.

Hessler, John C. *The First Year of Chemistry*, Sanborn, 1931. $1.68

McPherson, Henderson, and Fowler. *Chemistry for Today*, Ginn, 1930. $5.00

Newell, Lyman C. *Practical Chemistry*, Heath, 1922.

General Science

Corwin, W., and Corwin, M. J. *The Science of Discovery and Invention*, Harr, 1931. (Glimpses into chemistry, physics, astronomy, and geology for junior high school. $1.80

Corwin, M. J., and Corwin, W. *The Science of Plant and Animal Life*, Harr, 1931. (A study of plants and animals for junior high school.) $1.72

Wood and Carpenter, Our Environment Series, Books I, II, III, Allyn, 1928–28–31.

Mathematics

Brueckner-Anderson-Banting. *Mathematics for Junior High Schools*, Winston, 1931, Book 1, $1.00; 1931, Book 2, $1.00

Brueckner-Farnam-Woolsey. *Mathematics for Junior High Schools*, Winston, 1931, Book 3, $1.28

Physics

Coburn, Walter E. *High School Electricity Manual*, Wiley, 1932. (A high school text.) $1.35

Fuller, Brownlee, and Baker. *First Principles of Physics*, Allyn, 1932. (A high school physics text.) $1.35

Lake, C. H., and Unseld, G. P. *A brief Course in Physics*, Heath, 1931. (A textbook in physics.) $1.68

Fuller-Brownlee-Baker. *Laboratory Exercises to Accompany the Fuller-Brownlee-Baker Physics*, Allyn, 1932. $.75

Stewart-Cushing-Towne. *Physics for Secondary Schools*, Ginn, 1932. $1.72

Weed, H. T., and Rexford, Frank. *Useful Science*, Winston, Book 1, 1932, $.81; Book 2, 1931. (Junior high school texts.) $1.11

THINGS TO MAKE

Solar, Frank I. *Hand Craft Projects—Book 3*, Bruce, 1931. (An attractive list of projects for boys with complete directions for making each article.) $1.25

TOYS AND OTHER MACHINES

LaBerge, Armand J. *Speed Toys for Boys*, Bruce, 1928. (Detailed work in drawings for construction.) $1.25

TREES

Gilbert, Lydia N. *Our Most Popular Trees*, Sully, 1929. Forty-eight colored illustrations. $1.50

WATER

Holway, Hope. *The Story of Water Supply*, Harper, 1929. (A supplementary reader for the upper grades.) $1.25

WORKBOOK SERIES

Bridges, R. E., and Lee, W. C. *Directed Study Work Book for General Science*, Rand, 1931. $.96.

Hunter, G. W., and Whitman, W. G. *Workbook for Problems in General Science*, American, 1932. (A workbook for junior high school.) $.60

Hurd, Q. W. *Work-Test Book in Physics*, Macmillan, 1930. \$.64
Kingsley, N. H., and Menge, E. J. *Laboratory Studies, Demonstrations, and Problems in Biology*, Bruce, 1930. \$1.28
Powers and Johnson. *A Workbook in Chemistry*, Allyn, 1931. \$.60
Riley-Wight-Connor. *Health Workbook*, Allyn, 1931. \$.45
Wood and Carpenter. *Science Discovery Book*, Allyn. Book 1, 1930, \$.67; Book 2, 1930, \$.75; Book 3, 1931, \$.75

TEACHERS' REFERENCES

ELEMENTARY SCHOOL

Animals

Barrows, William M. *Science of Animal Life*, World, 1927. (A textbook.) \$1.76

Biography

Tracy, Henry C. *American Naturists*, Dutton, 1930. (Biographies of naturalists and scientists.) \$3.00

Biology

Conn, H. W. *Bacteria, Yeasts, and Molds in the Home*, Ginn, 1917. (Factual material for the teacher and the lay person.) \$1.60

Birds

Coward, T. A. *The Migration of Birds*, Macmillan, 1929. \$1.00
Kearton, Cherry. *The Island of Penguins*, McBride, 1931. \$3.00
Wetmore, Alexander. *The Migrations of Birds*, Harvard, 1930. (The results of the author's investigation over a period of twenty years are presented in a manner suitable for the ornithologist and the layman.) \$2.50

Child Study

Hill, Patty, and Others. *A Conduct Curriculum*, Scribner's, 1923. \$1.25

Conservation

Wilbur, R. L.-Du Puy, W. A. *Conservation in the Department of the Interior*, U. S. Government Printing Office, 1931. (Up-to-date information on a vital problem of the U. S. Delightful and helpful illustrations.) \$1.00

Earth

Stevens, Bertha. *Child and Universe*, Day, 1931. (Subject matter to aid parents in answering children's questions. It offers an idea for the makers of the primary school curricula.) \$3.75

Ecology

McDougall, W. B. *Plant Ecology*, Lea, 1931. (Written as a text and also as a useful reference for teachers.) \$5.00

Education

Bucknell University Bulletin. *Proceedings of the Conference on Education Held at Bucknell University*, Bucknell, 1931. (A report of the papers read at the 1931 educational conference.) Free
Carr, William, and Waage, John. *The Lesson Assignment*, Stanford, 1931. (A practical manual of the modern lesson assignment.) \$1.50
Case, Roscoe D. *The Platoon School in America*, Stanford, 1931. \$3.00
Curtis, Francis D. *Second Digest of Investigations in the Teaching of Science*,

Blakiston, 1931. (A source book containing digests of investigations in the teaching of science.) $3.00

Elsbree-Halsey-Elsbree. *The Teacher's Handbook*, Columbia U., 1929. (Question and answer method is used. The content is offered as an opportunity to check up on one's professional knowledge.) $2.50

Thralls, Z. A., and Reeder, E. H. *Geography in the Elementary School*, Rand, 1932. (A book not only for teacher training institutions, but one which gives suggestions and source material for teachers in service.) $2.40

Education—Child Development

McLester, Amelia. *The Development of Character Traits in Young Children*, Scribner, 1931. $1.25

Electricity

Jones, E. W. *Essentials of Applied Electricity*, Bruce, 1928. (Principles and applications of electricity are presented in language suitable for the beginner.) $1.36

Zeleny, Anthony. *Elements of Electricity*, McGraw, 1930. (A textbook.) $3.00

Evolution, Heredity, Eugenics

Altenburg, Edgar. *How We Inherit*, Holt, 1928. (A book on heredity for the general reader.) $2.40

Conger, George. *New Views of Evolution*, Macmillan, 1929. (One of the *Philosophy for the Layman* series. Evolution is presented as it occurs in physics, chemistry, geology, psychology, and sociology.) $2.50

Fasten, Nathan. *Origin Through Evolution*, Crofts, 1929. (The facts of evolution presented for the average student and the layman.) $3.00

Mason, Frances (Editor). *Creation by Evolution*, Macmillan, 1928. (Present day knowledge brought up-to-date by leading authorities in language suitable for the average reader.) $5.00

Pratt, Henry. *General Biology*, Harper, 1931. (A source book.) . . . $3.25

Forestry

Pack, Charles-Gill, Tom. *Forests and Mankind*, Macmillan, 1930. (A wealth of factual material for teachers. Good diagrams and illustrations.) $3.00

Gardening

Rush, Mary W. *The Ignoramus Garden Book*, Sears, 1931. (A beginner's handbook on gardening.) $2.50

General Reference

Abbot, Charles. *Everyday Mysteries*, Macmillan, 1930. (The science of familiar subjects is explained.) $2.00

Anonymous. *The Naturalists' Directory*, Cassino, 1931. (Names, addresses and special subjects of study of professional and amateur naturalists of North and South America.) $2.00

Cureton, E. E., and Rulon, P. J. *The Earth and Its Life*, Harvard, 1932. $1.00

Darwin, Charles. *A Naturalist's Voyage Round the World in H.M.S. "Beagle,"* Oxford, 1860. (A handy pocket edition of a science series.) $.80

Dietz, David. *The Story of Science*, Sears, 1931. (A popular treatment of a technical topic. Interesting and understandable for the lay reader.) $3.50

Geology

Cushing, Leverett, van Horn. *Geology and Mineral Resources of the Cleveland District, Ohio—Bulletin 818*, U. S. Government Printing office, 1931. $.65

Handbooks

Armstrong, Margaret. *Field Book of Western Wild Flowers*, Putnam, 1927. (A handy volume for the outdoor student.) $3.50

Heavenly Bodies

Nassau, Jason J. *A Textbook of Practical Astronomy*, McGraw, 1932. (A practical book of astronomy for those who wish to do some observational work.) $3.00

Newcomb, Simon. *Astronomy for Everybody*, Garden, 1932. (The science of astronomy has been brought up-to-date in this book.) $1.00

Shapley, Harlow. *Flights from Chaos*, Whittlesey House, McGraw, 1930. (From atoms to galaxies, a treatment of scientific themes for the lay reader.) $2.50

Insects

Howard, L. O. *The Insect Menace*, Century, 1931. (A teacher's reference, both elementary and high school. The importance of the warfare against insects is emphasized and the progress that man has made in controlling insects.) $3.50

Library

Brown, Zaidee. *The Library Key*, Wilson, 1931. (A guide which will save time for students and adults.) $.70

King, William A. *The Elementary School Library*, Scribner, 1929. (A book for persons who wish to establish and maintain a library in their schools.) $2.00

Man's Development

Storm, Grace E. *The Social Studies in the Primary Grades*, Lyons, 1931. (The principles, content, and technique of teaching the Social Studies in the kindergarten and primary grades.) $2.50

Manuals

Hunter, G. W., and Whitman, W. G. *Teachers' Manual and Key for General Science*, American, 1931. (For problems in General Science.) $1.00

White, M. L., and Hanthorn, A. *Teachers' Manual for Do & Learn Readers*, American, 1930. Book 1—first year, $.92; Book 2—second and third years, $.80

National Parks

Albright, H. M., and Taylor, F. J. *"Oh, Ranger!"*, Stanford, 1929. (A story of the National Parks. The stories of bears, Indians, mountains, and streams will enrich the experience of the summer to these regions.) $1.00

Scoyen, E. T., and Taylor, F. J. *The Rainbow Canyons*, Stanford, 1931. (A fascinating story of Zion and Bryce National Parks.) $2.00

Naturalists

Tracy, Henry C. *American Naturists*, Dutton, 1930. (Biographies of naturalists and scientists.) $3.00

Nature Study

Green, George R. *A Survey of Nature*, Slingerland, 1930. (Source book for students of nature.) $3.00

Pets

Cady, Bertha C. *Animal Pets*, Slingerland, 1930. (For the upper grades.) $.50

Photography

Neblette, C. B. *Photography, Principles & Practice*, Van Nostrand, 1927. (A comprehensive volume including both theory and practice in photography.) $6.50

Physical Science

Brownell, Herbert. *Physical Science*, McGraw, 1931. (Factual material for teachers and the lay person.) $2.50

Wendt, G., and Smith, O. F. *Matter and Energy—Volume 1*, Blakiston, 1930. (Source book for factual material and principles of science.) $1.50

Physics

Jordan, Arthur L. *Elementary Laboratory Aerodynamics*, Ronald, 1929. (A laboratory manual.) $.80

Plants

Matheny, William A. *Seed Dispersal*, Slingerland, 1931. (Factual material and methods for presenting subject matter.) $1.50

Simpson, Charles. *Florida Wild Life*, Macmillan, 1932. (A guide to the wild life of Florida for residents of the state and tourists as well as the nature lover.) $2.50

Thornber, John J., and Bonker, F. *The Fantastic Clan*, Macmillan, 1932. (Seventy-five most important cactus species are described. Complete culture directions for handling them indoors and outdoors are given.) $3.50

Radio

Perry, Armstrong. *Radio in Education*, Payne, 1929. ("The Ohio School of the Air" and "Earlier Experiments in the Use of the Radio in Education.") $1.00

Ships

Calahan, Harold A. *Learning To Sail*, Macmillan, 1932. (A practical book for those who wish to sail a small boat.) $3.00

Hawks, Ellison. *The Romance of the Merchant Ship*, Crowell. (A story of the development of ships from the crude crafts of early man to the giant ocean liners of today. Excellent illustrations.) $3.00

Teaching of Elementary Science

Billig, Florence G. *A Technique for Developing Content for a Professional Course in Science for Teachers in Elementary Schools*, Columbia U., 1930. (This study includes the analysis of the background of students in teacher training institutions.) $1.50

Craig, Gerald S. *Certain Techniques Used in Developing A Course of Study in Science for the Horace Mann Elementary School*, Columbia U., 1927. (A method of developing a course of study in Elementary Science.) $1.50

Hillman, James E. *Some Aspects of Science in the Elementary Schools*,

George Peabody College for Teacher, 1924. (An investigation of the status of science in the schools.) $1.00

Meier, Lois. *Natural Science Education in the German Elementary Schools*, Columbia U., 1930. (A descriptive account of present-day practices in the teaching of natural science in German elementary schools.) $1.75

National Society for the Study of Education. *A Program for Teaching Science, Thirty-first Yearbook, Part I*, Public, 1932. (Current practices and the best thought in psychology and philosophy are included.) $1.75

TESTS AND MEASUREMENTS

Gates and Others. *The Modern School Achievement Tests*, Columbia U., 1931. $7.20 per 100

MacDonald, Marion E. *Practical Statistics for Teachers*, Macmillan, 1930. (A workbook.) $1.60

Ruch, G. M., and Rice, G. A. *Specimen Objective Examinations*, Scott, 1930. (A teacher's reference.) $1.80

Thurstone, L. L. *The Fundamentals of Statistics*, Macmillan, 1931. (Details of statistical procedure are presented in such simple terminology that teachers who are without extensive training in statistical methods can make use of and interpret the content.) $2.00

Tiegs, E. W., and Crawford, C. C. *Statistics for Teachers*, Houghton, 1930. $1.90

TREES

Fry, Walter, and White, John. *Big Trees*, Stanford, 1930. (The largest and oldest of living things are described.) $2.00

Gilbert, Lydia N. *Our Most Popular Trees*, Sully, 1929. (Forty-eight colored illustrations.) $1.50

WATER LIFE

Beebe, William. *Nonsuch*, Brewer, 1932. (One of a series of four volumes dealing with life in the water about Nonsuch, Bermuda. Attractive illustrations.) $3.50

WEATHER

Elm, Captain Ienar E. *Weather and Why*, McKay, 1929. (The applications of the principles of meteorology as they are needed in piloting a plane.) $2.50

Piston, Donald S. *Meteorology*, Blakiston, 1931. (An excellent source of information.) $2.50

Van Cleef, Eugene. *The Story of the Weather*, Century, 1929. (The applications of science to weather forecasting are presented for the layman.) $2.50

JUNIOR AND SENIOR HIGH SCHOOL

BIOLOGY

Belling, John. *The Use of the Microscope*, McGraw, 1930. (Principles and operation of the microscope explained.) $4.00

Caldwell, Skinner, and Tietz. *Biological Foundations of Education*, Ginn, 1931. $2.72

Carnegie Institution of Washington. *Year Book—Number 30*, Carnegie Institution of Washington, 1931. (A report of research in the sciences and the problems being investigated.) $1.00

Chidester, F. E. *Zoology,* Van Nostrand, 1932. (Good source book for animal study.)

Conn, H. W. *Bacteria, Yeasts, and Molds in the Home,* Ginn, 1917. (Factual material for the teacher and the lay person.) $1.60

Eikenberry, W. L., and Waldron, R. A. *Educational Biology,* Ginn, 1930. (A textbook in biology.) $2.48

Gardner, Bradford, and Hooker. *The Fundamentals of Fruit Production,* McGraw, 1922. $4.50

Giesen, John, and Malumphy, Thomas. *Backgrounds of Biology,* Bruce, 1929. (A teacher's reference.) $2.50

Harman, Mary T. *A Textbook of Embryology,* Lea, 1932. (This is useful not only as a text, but as a handy reference for teachers.) $4.25

Johnson, John. *Educational Biology,* Macmillan, 1930. (A textbook for biology.) $3.00

Needham, J. G., and Needham, P. R. *A Guide to the Study of Fresh-water Biology,* Thomas, 1930. $1.00

Nelson, George E. *The Introductory Biological Sciences in the Liberal Arts College,* Columbia U., 1931. $1.50

Peirce, George J. *Experimental Plant Physiology,* Holt, 1931. (Suggested experiments for teachers.) $1.50

Plunkett, Charles R. *Outlines of Modern Biology,* Holt, 1930. $3.75

Rigg, George B. *College Botany,* Lea, 1930. (A general reference for teachers.) $4.00

Robbins, Wilfred W. *The Botany of Crop Plants,* Blakiston, 1931. (Useful information and splendid illustrations for teachers.) $4.00

Shumway, Waldo. *Textbook of General Biology,* Wiley, 1931. $3.00

Smallwood, William M. *A Textbook of Biology,* Lea, 1930. (A teacher's reference and source book for biology subject matter.) $4.00

Weldon, George P. *Economic Biology,* McGraw, 1929. (A textbook and general reference for biology.) $2.50

Wheat, Frank, and Fitzpatrick, Elizabeth. *General Biology,* American, 1931. $1.80

Biology—Course of Study

Coulter, Merle, and others. *Introductory General Course in the Biological Sciences—Syllabus,* University of Chicago, Sept. 1931. (A detailed outline with complete bibliography.) $1.10

Tennessee State Board of Education. *Tentative Biology Syllabus for County High Schools,* Tennessee, 1932. (A state course of study.) $1.00

University of the State of New York. The State Education Department. *Tentative Syllabus in General Biology,* University of the State of New York Press, 1931. (Units for high school biology.) $.10

Building

Anonymous. *Light Frame House Construction,* Federal Board for Vocational Education, 1930. (Technical information for the apprentice and the journeyman carpenters.) $.40

Chemistry

Glasstone, Samuel. *Recent Advances in Physical Chemistry,* Blakiston, 1931. (Meets the need of the chemist and the student in keeping up with chemistry.) $3.50

Hodgman, C. D., and Lange, N. A. *Handbook of Chemistry and Physics—16th Edition*, Chemical Rubber Publishing Co., 1931. (This revised edition contains the suggestions of those who have used the former edition.) $2.75

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TO HAVE OR TO BE

We are just recovering from one of the worst afflictions that can happen to any nation—a period during which large numbers of people received something for nothing. That strange historical interlude developed a philosophy of its own, for no system of action can hope to survive without some sort of a concrete philosophy behind it. The disastrous philosophy in this case was that of "results." Size was substituted for contents and quantity for quality. As a result, the old ideal of "being" was allowed to be forgotten for a new ideal of "having."—*H. W. Van Loon in N. E. A. Journal.*

HOW MUCH ARITHMETIC AND ALGEBRA DO STUDENTS OF FIRST YEAR COLLEGE PHYSICS REALLY KNOW?

By William R. Lueck, *Iowa City, Iowa*

Teachers of first year college physics frequently complain of serious mathematical weakness among students enrolled in their classes. The data of the study reported herewith leave no doubt as to the validity of these complaints. However, if the solution of mathematical problems continues to be an important phase of the course in physics, then active steps must be taken to insure that the students have a mastery of the necessary mathematical skills. It is the purpose of this article to lay the foundation for a remedial program by setting forth the achievement and disabilities of first year college physics students in arithmetic and algebra.[1]

ACHIEVEMENT IN ARITHMETIC AND ALGEBRA

Procedure. In December, 1930, the *Compass Survey Test in Arithmetic* (*Advanced Examination*)[2] and the *Douglass Diagnostic Test in Elementary Algebra* (*Series B, Form II*)[3] were given to 280 students of first year college physics in five Iowa colleges. The tests were administered and scored according to directions furnished by the publishers. The scores were tabulated and the necessary statistical measures found.

Achievement in arithmetic. No student solved all of the sixty problems on the Compass Test correctly. Twenty-eight per cent of the students exceeded a score of fifty while seventy per cent exceeded a score of forty. The mean number of problems solved correctly was $44 \pm .53$,[4] or seventy-four per cent of the problems in the test. This is equal to the achievement of the lower half of the seventh grade.

In Table 1 the scores are so grouped that each interval begins with a certain grade norm. The first column at the left of the table gives the grade level, the letters H and L indicating the

[1] The complete study, of which this article is a small part, is on file at the College of Education Library, State University of Iowa, in the form of a Doctor's dissertation.

[2] The Compass test samples in a reasonable way what may be termed the minimum essentials in arithmetic. The content is relatively simple. The test is published by Scott, Foresman and Company Chicago.

[3] The Douglass test contains materials of representative difficulty intended for the second semester's work in high school algebra. It may be obtained from the Bureau of Administrative Research, University of Cincinnati.

[4] The standard error is used as a measure of reliability in this report.

TABLE 1

PERCENTAGE OF STUDENTS WHO ATTAINED AND EXCEEDED VARIOUS GRADE NORMS ON THE COMPASS SURVEY TEST

Grade Level	*Grade Norm*	*Frequency Between Grade Norms*	*Percentage of Total*	*Cumulative Percentage of Total*
H8	52	55	20	20
L8	50	28	10	30
H7	47	41	15	45
L7	44	34	12	57
H6	39	57	20	77
L6	33	38	13	90
H5	26	20	7	97
L5	21	5	2	99
H4	16	2	1	100

upper and lower halves of the grade in question. The table for the lower half of the eighth grade or L8 reads as follows: The norm for this grade is 50. There were 28 students at or above the norm for L8, but below the norm for H8. This is ten per cent of all the students taking the test. The cumulative per cent column tells us that thirty per cent of the 280 students attained or exceeded the norm for L8. Similarly, the percentage of students attaining and exceeding other grade levels may be obtained from the table. One-fifth of the students attained and exceeded the norm for H8. In general, these students approximate very closely seventh grade ability in arithmetic.

Achievement in algebra. The Douglass Test for the second semester of high school algebra contains thirty-five problems. The mean number of problems solved correctly by the 265 students who took all of the test was $16.4 \pm .50$, or forty-seven per cent. High school students who are just completing their first year of algebra attained a mean score of 21.8. Only twenty-seven per cent of the students exceeded the high school norm.

Influence of college mathematics. Of the 280 students who took the previously mentioned tests, 120 had pursued or were taking courses in college mathematics. The remainder had no mathematical training beyond that received in high school. What is the difference in the attainments of the two groups? Table 2 shows the mean achievement of the two groups separately and when combined. The students who had pursued courses in college mathematics attained higher mean scores in both arithmetic and algebra. The difference between the means in arithmetic is $3.7 \pm .96$; in algebra it is $6.7 \pm .92$. In both cases the

TABLE 2

COMPARISON OF COLLEGE AND HIGH SCHOOL GROUPS IN ACHIEVEMENT

	Arithmetic		*Algebra*	
Group	*Mean Number of Problems Correct*	*Standard Deviation*	*Mean Number of Problems Correct*	*Standard Deviation*
High School	$42.6 \pm .72$	9.17	$13.6 \pm .58$	7.13
College	$46.3 \pm .63$	6.89	$20.3 \pm .72$	7.61
Both Groups	$44.2 \pm .53$	8.83	$16.4 \pm .50$	8.16

difference is more than three times its standard error. The formula[5] for the standard error of a difference, which has been used here, is applicable only if the two groups in question are selected at random. This condition is not strictly satisfied by the samples used in this study. The direction of the difference, however, is clearly evident. For the groups in question, college training has had a decided influence on achievement in algebra while its effect on arithmetical ability is less marked.

DISABILITIES IN ARITHMETIC AND ALGEBRA

In the previous section we were concerned with the scores obtained by students of first year college physics on standard tests in arithmetic and algebra. The relatively low attainments of the group in question suggested the possibility of a considerable amount of disability in the branches of mathematics named. It will now be our purpose to list the operations in which many errors occurred and the extent of each difficulty as shown by the percentages of incorrect responses.

Method of procedure. To obtain the various disabilities of any particular student as indicated by the tests, every problem incorrectly solved by him was analyzed. If the student's work indicated that he had obtained a wrong answer merely because of a computation error, only this specific difficulty was recorded. If his efforts indicated a hazy understanding of the whole process, his disability was recorded as such. The process or operation in which a disability was found was named and given a number. Subsequent errors of this nature were recorded by tally marks following the numbers. Other disabilities were classified and recorded in the same manner.

In order to find the percentage of incorrect responses to any operation it was necessary to determine the actual frequency of an error and the total number of opportunities for all the

[5] Garrett, Henry E., *Statistics in Psychology and Education*. Longmans, Green and Company, New York, 1930. p. 129.

students to make that error. Both of these items were obtained by actual count. The actual frequency was then divided by the total possible frequency giving the percentage of inaccuracy for the operation in question.

TABLE 3

PERCENTAGE OF INCORRECT RESPONSES TO TWENTY ARITHMETICAL OPERATIONS BY 280 STUDENTS OF FIRST YEAR COLLEGE PHYSICS

Number	*Disability*	*Illustrative Example*	*Percentage of Error*
1	Changing per cents to decimals	$6\frac{3}{4}\%$ to .0675	47
2	Dividing a proper fraction by a decimal	$\frac{5}{8} \div 2.5$	44
3	Dividing a mixed number by a mixed number	$7\frac{4}{9} \div 3\frac{2}{5}$	41
4	Changing a mixed number to per cents	$3\frac{4}{5}$ to 380%	37
5	Changing per cents to a fraction (100% or more)	125% to $1\frac{1}{4}$	36
6	Finding a number, given more than 100% of it	Find N if 125% of N is 250	36
7	Finding a number, given less than 100% of it	Find N if 30% of N is 15	35
8	Subtracting denominate numbers	3 yd. 5 ft. 1 yd. 7 ft.	31
9	Adding denominate numbers	1 ft. 10 in. 8 ft. 4 in.	29
10	Multiplying denominate number by an abstract number	7 yd. 3 ft. by 4	28
11	Changing per cents to a fraction (100% or less)	$62\frac{1}{2}\%$ to $\frac{5}{8}$	27
12	Finding what per cent one number is of another number	What per cent of 8 is 3?	26
13	Finding a certain per cent of a number	5% of 63	24
14	Dividing a proper fraction by a proper fraction	$\frac{5}{8} \div \frac{4}{5}$	23
15	Changing a decimal fraction to per cent	.004 to .4%	22
16	Multiplying a proper fraction by a proper fraction	$\frac{7}{8} \times \frac{4}{5}$	22
17	Dividing a denominate number by an abstract number	9 yd. 2 ft. by 4	21
18	Multiplying a decimal quantity by a mixed number	$10.68 \times 2\frac{1}{4}$	20
19	Subtracting mixed numbers	$11\frac{3}{4} - 4\frac{7}{8}$	18
20	Multiplying a whole number by a fraction	$42 \times \frac{3}{4}$	18

Results in arithmetic. Table 3 presents the twenty arithmetical operations in which the percentage of error was eighteen or more. The highest percentage of wrong solutions occurred in the process of changing a certain per cent to a decimal. Nearly half of the students, or forty-seven per cent, failed to solve problems of this type correctly. Problems involving division of a proper fraction by a decimal quantity were solved incorrectly by forty-four per cent of the students. Dividing a mixed number by a mixed number brought forty-one per cent error. Changing a mixed number to per cent was failed to the extent of thirty-seven per cent. In the process of changing per cents to fractions, the percentage of error was thirty-six. The fact that the number of the per cent to be changed is above or below a hundred does not significantly alter the result. A surprisingly high percentage of error occurred in operations with denominate numbers. In the subtraction of denominate quantities the percentage of error was thirty-one. Disabilities in other arithmetical operations occurred with decreasing percentages of error.

In Table 4, the fifty-three operations in which disabilities were found have been grouped into six broad categories. For each group the mean percentage of inaccuracy has been calculated. The percentage of error in operations involving decimals only, or fractions only is rather low. When the two are combined in a test item the percentage of error is increased to thirty-seven. Combining fractions and percentage, or percentage and interest gives similar results. The facts of Table 4 point to the conclusion that the percentage of error is dependent in part upon the complexity of the operation.

TABLE 4

MEAN PERCENTAGE OF ERROR ON GENERAL TOPICS IN ARITHMETIC

Type of Operation	*Mean Percentage of Error*
Operations with decimals and fractions combined	37
Operations with fractions and percentage	33
Operations with percentage and interest	30
Operations with decimals and percentage	29
Operations with fractions only	13
Operations with decimals only	5

Results in algebra. Table 5 presents the twenty-five algebraic operations in which disabilities occurred with percentages of

inaccuracy of eighteen or higher.[6] The table is read and interpreted in exactly the same manner as Table 3.

Many operations in elementary algebra present great difficulty to students of first year college physics. The first sixteen operations in Table 5 were performed with an inaccuracy of more than fifty per cent. The solution of a quadratic equation by the method of completing the square was most difficult with ninety-three per cent error. The graphical solution of two simultaneous linear equations was accomplished by less than twenty per cent of the students. In the process of rationalizing a fractional radicand, the percentage of error was seventy-nine. Much difficulty was encountered in operations involving radicals as numbers 3, 5, 6, and 11 will indicate. The same is true of fractions, exponents, quadratic and fractional equations, and even simple graphing.

TABLE 5

PERCENTAGE OF INCORRECT RESPONSES TO TWENTY-FIVE ALGEBRAIC OPERATIONS BY 265 STUDENTS OF FIRST YEAR COLLEGE PHYSICS

Number	*Disability*	*Illustrative Example*	*Percentage of Error*
1	Solving a quadratic equation by completing the square	$x^2-7x=-12$	93
2	Solving graphically a linear system of two equations	$a+b=15$ $a-b=\ 3$	81
3	Rationalizing a fractional radicand	$\sqrt{x/5}$	79
4	Dividing quantities involving literal exponents	$x^{2n-2}+x^{n-1}$	78
5	Combining radicals	$\sqrt{32}-\sqrt{18}$	71
6	Solving a fractional quadratic equation	$x/(x-2)-x=5$	71
7	Simplifying an irrational radicand	$\sqrt{72}$	68
8	Solving a linear fractional system of equations	$x/3-y/4=4$ $x/2+y/2=7$	67
9	Forming a quadratic equation from given data		63
10	Combining fractions having polynomial and monomial parts	$(a-b)/b-a/(b-a)$	60
11	Changing a mixed quantity to a fraction	$xy-x^2-y^2/xy$	60
12	Extracting a rational root	$\sqrt{64x^4}$	60

[6] Thirty-one other disabilities were found with lower percentages of error.

TABLE 5 (*continued*)

Number	Disability	Illustrative Example	Percentage of Error
13	Solving a linear fractional equation	$(x+5)/4-(x-3)/5=2$	59
14	Interpreting a bar graph		58
15	Solving a quadratic equation	$x^2-5x=6$	54
16	Multiplying monomial fractions	$a^2b/c^2a\cdot a/b$	53
17	Constructing the graph of a linear equation	$2a=5s$	53
18	Raising a quantity to a higher power	$(x^2)^3$	49
19	Solving for a certain variable in a formula	Solve for b: $A=\frac{1}{2}h\cdot b$	46
20	Forming a linear system of equations from given data		45
21	Factoring by removing a common monomial	$ab+ac=a(b+c)$	37
22	Reducing a monomial to lowest terms	$24a^3b/48ab$	36
23	Factoring a general quadratic trinomial	$6x^2-x-12$	35
24	Solving simultaneous equations	$3x+2y=5$ $4x+3y=7$	30
25	Applying the Pythagorean principle in right triangles		27

Table 6 shows the mean percentage of error for general classes of operations. This table was obtained by grouping the fifty-six algebraic disabilities listed in the original study, and includes the items in Table 5. The greatest difficulty is presented by radicals, roots, and exponents, the percentage of error being

TABLE 6
MEAN PERCENTAGE OF INACCURACY ON GENERAL TOPICS IN ALGEBRA

Type of Operation	Mean Percentage of Error
Operations with radicals, roots, and exponents	53
Operations with graphing	36
Operations with equations and formulas	31
Operations with factoring	29
Operations with fractional equations	28
Operations with fractions only	21

fifty-three. The remaining groups, by their percentage of inaccuracy, indicate that all the advanced topics in elementary algebra are stumbling blocks for many students of beginning physics.

Nature of the disabilities. Of the 3,700 disabilities in arithmetic tabulated in this analysis, 1,082 or twenty-nine per cent, were of a type best characterized by omission of the problem or feeble efforts at solution. Many students, however, were capable of correctly starting the solutions to problems. But having started the solutions, they were unable to complete the remaining operations correctly, or did not possess the mastery of a certain skill within the solution. Eighteen per cent of the errors belong to this second group. Nearly one-fifth (19%) of all the arithmetical disabilities were errors in the fundamental number combinations, carrying, borrowing, and the like. The Compass Test requires that fractional answers be reduced to lowest terms. In spite of this fact, twelve per cent of the arithmetical disabilities indicated neglect of this requirement. Incorrect placing of the decimal point and its complete omission in the answer when necessary accounted for eight per cent of the errors. Other disabilities such as faulty copying, illegible penmanship, and misinterpretation of the problem occurred with low frequency. It should be noted that two-thirds of all the disabilities are contained in the first three classes enumerated.

The outstanding fact revealed by the algebraic analysis is the unusually high proportion of problems omitted and those characterized by impossible and meaningless solutions. Fifty-six per cent of the 4,490 disabilities in algebra were of the type just described. In twenty-two per cent of the disabilities, students failed on one or more skills within a solution, after starting the work correctly. Computation errors in the four fundamental processes as applied to algebra, carrying, and borrowing accounted for eight per cent of all the errors. These three classes represent eighty-six per cent of the total errors found. The remainder, or fourteen per cent, was distributed among twelve additional classes each with low frequency.

Dr. Irving Langmuir, General Electric chemist, who has been awarded the 1932 Nobel prize in chemistry, is the seventh American scientist to be honored with a Nobel prize. Only one other American, the late Prof. T. W. Richards of Harvard, has been awarded the chemistry (1914) laureate. The late Prof. A. A. Michelson, University of Chicago physicist, was the first American recipient, when in 1907 he was honored for his work. The other American Nobelists, all living, are: Dr. Alexis Carrel of the Rockefeller Institute for Medical Research, medicine, 1912; Dr. R. A. Millikan, of the California Institute of Technology, physics, 1933; Dr. Arthur H. Compton of the University of Chicago, physics, 1927; Dr. Karl Landsteiner of the Rockefeller Institute for Medical Research, medicine, 1930.

CRYSTAL GROWING AS A HOBBY

By Henry J. Long
Greenville College, Greenville, Illinois

Growing crystals furnishes an interesting pastime for a Chemistry teacher. A number of articles have appeared in the journals during the past three or four years on the general subject of crystals. Following the suggestions of the article by F. A. Rohrman and N. W. Taylor of the University of Minnesota (*Journal of Chemical Education* 6:473) we have been growing some crystals in Greenville College. It was begun as a student project and it proved to be one in which the students took much interest. Later it was continued by the department as a teaching project with the idea of eventually preparing at least one or two of each of the common types of crystals for the display cabinet to be used in teaching. It was thought that a crystal from two to four ounces in size to be handled by the student would give him a much better picture of a crystal type than a picture in the book or even a view through a lens in the laboratory.

By far the largest crystal grown here has been one of chrome alum which was grown for eight or nine months. It weighs 4.8 kilograms or about ten and one-half pounds. With the exception of one minor defect it is practically a perfect crystal. It measures about ten and one-half or eleven inches between opposite corners.

The authors of the above mentioned article recall the fact that nature is very methodical in repairing her broken crystals in a remarkably short time. With this in mind a perfect chrome alum crystal about one and one-half inches in diameter was sawed as nearly as possible through the center, and parallel to two opposite faces. These two half crystals were then placed back to grow. The regularity with which these two halves developed was very interesting. In about a month or six weeks the two halves had become almost perfect crystals again somewhat larger than the original one had been when cut.

A four tone crystal was attempted as follows: An ordinary potassium alum crystal was grown to about three quarters of an inch in diameter. It was then transferred to a solution of chrome alum and a layer of it deposited about an eighth of an inch

thick. It was then placed in another clear alum solution. Ferric alum was used this time. It was left until it had grown about three-sixteenths of an inch thick over the chrome alum. Finally it was placed in another dark alum solution. Chromium ammonium alum was used instead of the ordinary chromium potassium alum which had been used for the second layer. This was allowed to grow about a quarter inch layer over the whole. However, due to some error while growing the fourth layer a small hole was left in that layer. Evidently due to the high solubility of the ferric alum (or possibly to a solution which was too warm) a large share of the ferric alum dissolved out leaving a hollow space in place of the third layer. This was not discovered until later then the finished four tone crystal was sawed in halves for the purpose of lacquering and mounting for an exhibit. When the crystal was sawed it was found to resemble a loose nut in its shell, the nut being made of the first two alums. The kernel was removed and the remaining soluble ferric alum washed out and the outer shell cemented together by means of a glue made mainly of rosin dissolved in benzene. This hollow shell on being placed back in the ammonium chromium alum continued to grow, gradually displacing of covering the glue and soon becoming a nice smooth crystal again. So the four tone crystal seems to have come out as a two tone crystal and a hollow crystal.

Other salts which were found to grow large crystals nicely were blue vitriol, Epsom salt, Rochelle Salt, ordinary alum, nickel sulfate, potassium ferrocyanide, and potassium ferricyanide, the last having now grown to a length of 13 inches.

Perhaps preserving the crystals after they are grown requires more patience than any other part of the work. At least ten or twelve types of varnishes, and lacquers have been tried with varying success. Some crystals are much more easily preserved than others. The most of the hydrates tend to lose their water of crystallization and become discolored. Water proof varnish, ordinary shellac, auto gasket shellac, collodion, quick drying lacquer, clear linoleum lacquer and a number of home made lacquers were tried. Practically all of the crystals were fairly well kept by one or another of these coverings except the chrome alum. At present the chrome alum crystals are being kept in an atmosphere saturated with water vapor by keeping a small vessel containing water in the inclosed space.

THE MICRO PROJECTOR AS AN AID IN THE TEACHING OF BIOLOGY AND GENERAL SCIENCE

By Edward W. Bossing
Crane Technical School, Chicago Illinois

One of the major problems confronting the teacher of Biology and general Science has been an adequate presentation of the microscopic world. Many teachers are even attempting to offer this branch of science without equipment. Others have only a single microscope. To make matters worse the average instructor finds that his student load has been increased while the orders for equipment have been temporarily reduced. Under such conditions this very valuable and interesting field of study has suffered the most. Even where a school has a complete complement of instruments the teaching of what to see, and how to use the microscope still remain as problems.

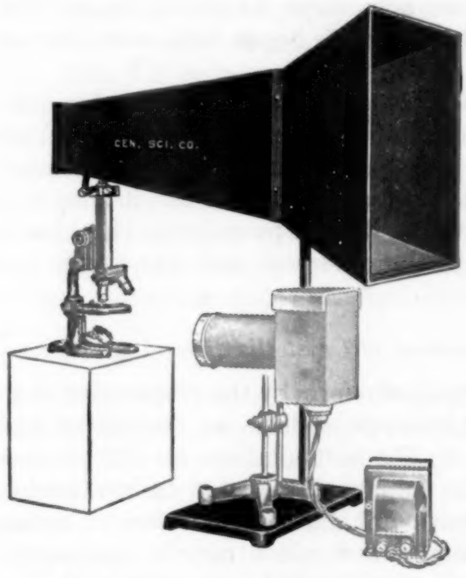
Individual use of the microscope by the high school student has been believed by some to be a waste of time. Since the beginner spends more time in learning what to see and how to see than he does in actual seeing, this criticism has been in part justifiable. An instructor on the other hand, cannot assist more than one beginner at a time at a microscope. Hence, much valuable time is lost and interest naturally cannot be properly maintained.

The materials for study are also so varied that to furnish good specimens for a large class often becomes impossible. Obviously, teacher demonstration is the only logical way out. But with the material under a single microscope, the calling of thirty-five to fifty students one by one to "come and see," becomes an impossible situation for the teachers and one whose end result from the standpoint of the student is of very doubtful value.

The use of a microprojector has long been recognized as a solution for the above and many other allied problems. The basic principle of these instruments is simple. It is merely the passing of a powerful light through a microscope attachment in such a way that the microscope becomes a projector. The image under the microscope then instead of being something to be seen by a single eye, becomes an image which is projected upon a screen for an entire group to see at one time. The values are obvious. Each member of the group actually sees the material to be studied and while all are observant, the salient points are

logically indicated by the instructor. Here is economy of time and unified interest.

Projectors of the past have usually been too complicated for the average instructor to use, or else the price has been prohibitive. We now have microprojectors as simple to use as a microscope. These are simple projection devices that fit on to the regular microscope and the source of light may be a regular projection lantern. Simple devices of this type can now be secured from leading dealers in scientific supplies for a price around fifteen dollars.



An Inexpensive Microprojector

Naturally the classroom teacher asks two pertinent questions which we will try to answer in the light of classroom experience. First, how does the microprojector solve the problem of microscopic classroom study? and secondly, just how is one of these machines used?

The first question may be answered by suggesting the place a projector fills in actual use in the classroom. In life we do not enjoy exploration when we are alone. Exploration by a group into the microscopic world with an instructor as guide is psychologically sound and satisfying. The microprojector permits the teacher to point out details and insures a true conception of objects. Individual microscopic study can hardly give such a

true conception to the beginner when unassisted by projection. While individual microscope work is an objective for the average teacher, everyone recognizes that other than a disconnected study is difficult because of the vastness of material. By projection these gaps can be quickly filled by the instructor and intense interest maintained. On the other hand where individual microscopes are a part of the regular equipment the work can be very greatly speeded up, and made easier and more interesting, by a five or ten minute preliminary demonstration of the material with the microprojector. Thus, when each student turns to his own microscope, he already has an idea of what he is to see and his work is begun with more interest and confidence.

The second question the classroom teacher asks, "Just how can I use a microprojector in my classroom and what are some of the projects successfully used by other teachers?" While the following is in no way a complete list, it aims to give detailed instruction of a few definite procedures. These instructions have been tested in the classroom with the simple projector mentioned above.

1. *The Phenomena of Crystallization*

Causing crystals to form by the evaporation of a drop of solution on a microscope slide is an interesting and instructive demonstration, The best solutions for this purpose are ammonium chloride, sulphur dissolved in carbon disulphide, sodium, nitrate, copper sulphate, sodium chloride, potassium bichromate, and some others which may be determined by trial. A drop of the solution should be spread very thinly on a grease-free slide, placed on the stage of microscope and as the solution evaporates the formation of crystals is projected on the screen making an interesting, instructive and beautiful picture. In some cases, the evaporation could be hastened by warming slide before placing on microscope stage. Unless the solution is spread very thinly on the slide several layers of crystals will form and the image on the screen will be somewhat indefinite.

2. *Observation of the blood stream in veins and arteries of a frog.*

Anaesthetize a frog or a tadpole by placing it in a bottle with a wad of cotton containing a few drops of ether or chloroform. Care should be taken not to leave it too long in this atmosphere as it will either be killed or rendered unfit for demonstration.

Secure the anaesthetized frog to a thin piece of wood. A cigar box top with a hole one-half inch in diameter toward one end will prove satisfactory. Wrap the frog in a long strip of moist cheesecloth. This not only aids in keeping it alive, but helps to keep it secure on the board while examination is in progress. Strong rubber bands are perhaps the most accessible means of attaching the swathed frog to the board. Arrange the animal on the board so that the web of one foot is over the hole. The web may be fastened over the hole by means of thread tied to the toes and fastened to small tacks in the board at the edge of the hole. Place frog and board on stage of microscope so that the hole in the board is properly centered under sixteen mm objective and that light will be transmitted through a portion of the web. It may be necessary to support the board and frog with proper arrangement of books, etc. or by tying board to stage of microscope with cord. The differences between arteries and veins may be easily observed. The passage of corpuscles through the capillaries in single file makes a most interesting projection. Occasionally the passage of a white corpuscle,(diapedesis), into the surrounding tissues may be seen.

3. *Streaming Protoplasm*

Living plant cells in which the movements of protoplasm can be seen and studied with the projector may be used by mounting a small portion of Chara on a slide. This makes an excellent demonstration to show this phenomenon. The streaming of the protoplasm takes place in the internodal cells. It is better not to add a cover glass unless it can be done very carefully to avoid any pressure. A very slight rise in temperature speeds up the movement within the cells.

The heat from the light source will take care of this. Observed under the high power the movements are very rapid.

If Chara cannot be procured, then Elodea leaf may be used. The stamen hairs of Tradescantia is also an excellent preparation. Even the common onion will show this if mounted correctly. The epidermis from an inner scale of the bulb is stripped off and mounted in a drop of water on a slide. A very weak aqueous solution of eosin will give a bit of color to the projection.

4. *Observation of Stomata in Plants*

Strip from the under side of a leaf a small piece of the epidermis. In floating leaves of water plants, it is the upper side

of the leaf. Excellent material to use for this demonstration is the leaf of the Paeony, Geranium, or Fuchsia. Mount the section in a drop of water on a slide under a cover glass. The stomata should be clearly observed and as drying takes place, closing of the stomata can be observed.

5. *Prepared Microscope Slides*

Those slides having greatest contrast in color and in structure will be found to project best.

Cross and longitudinal sections of plant stems may be studied under the high and low power. For gross examination of such prepared slides the upper half of the 16 mm objective will prove very effective. This may be obtained by unscrewing the tip of the objective. Fibro-vascular bundles of monocotyledonous stems may be studied in minute detail by projecting with the high power, although low power examination will usually suffice. Annular rings of some dicotyledonous stems may be observed and periods of wet and dry years noted by the width of the ring.

Nearly all animal tissue slides make very good subjects for microprojection. If a complete cross-section of a certain piece of tissue is desired for projection the use of the upper half of the low power is advised. After obtaining the relationship of the different strata of tissues with this low power projection, each one of these layers of tissue can be studied in detail under the regular low and high power (16 mm and 44 mm).

6. *Preserved Specimens*

Preserved materials often make very excellent subjects for projection. We call attention to a few preserved materials that will prove interesting as well as highly instructive:

(1) Hydra, with buds
(2) Obelia, expanded
(3) Planaria
(4) Ascaris lumbricoides
(5) Amphioxus, small
(6) Vaucheria
(7) Volvox
(8) Spirogyra
(9) Gleocapsa
(10) Pandorina

Such preserved material is best used by putting a very small portion of it in a concave depression slide.

7. *Insects and Insect Structures*

Such mounts, whether carefully made permanent slides or temporary mountings only of the specimen on a slide, are among the very best subjects for microprojection. Of the many mounts of this character that can be used in the general science or biology class we recommend:

a. Various insect antennae
b. Wing venation
c. Scales of butterfly and moth wings
d. Mouth parts of various insects, such as the proboscis of a fly or moth, the palps of a small beetle or honey bee, the mouth parts of a beetle or any other dissection of a similar character.
e. Head of a mosquito. Especially good for general anatomy of insects.
f. The aphid or milk cow of the ant. Mounts are easily made by placing the animal in 95 per cent alcohol for about fifteen minutes, then clearing in cedar oil for the same length of time, and finally mounting permanently in Canada Balsam on a slide. A concave depression slide is excellent for such mounts. Whole mounts of lice, ticks, fleas, ants, and other small specimens may be prepared in the same manner, and shown with the upper half of the 16 mm objective.

8. *Living Cultures*

Perhaps no other picture to be obtained with the microprojector is quite as fascinating and instructive as the projection of living cultures of paramoecia and amoebae. Students never tire of watching the erratic movements of these microscopic animals. Cultures of a few of the Protozoa can be very easily grown in the laboratory. A simple hay infusion usually gives very good results for a few days. This type of culture, however, does not give as good results as pure cultures that have been seeded. These may be prepared by boiling a quart of water into which is placed forty to seventy grains of wheat. Allow this to ripen for ten days and then seed with a pure culture which has been purchased or the desired Protozoa may be selected by picking them out with a very fine pipette. Pipettes for this purpose may be made by drawing out a glass tube in a Bunsen flame. It may be noted here when making cultures with wheat that care must be taken to not boil too long. The berry must remain whole as the starch spoils the culture.

For projection, organisms are best placed in a Syracuse watch glass in a few drops of the same water in which they were taken. The watch glass absorbs the heat from the light source, keeping the temperature of the culture about correct. Since evapora-

tion is rather rapid due to the heat, water should be added from time to time if the culture is expected to live. The 16 mm objective is preferable for such cultures.

Living cultures of Rotifers make very interesting projections and are not nearly as common as either the paramoecium or amoeba. Rotifers may usually be found in old cultures.

9. *Miscellaneous Organisms*

Mosquito larvae, hydra, planarians, and other similar organisms may be projected in the living state showing the entire body if the low power objective is unscrewed and the upper part only, used. Specimens should be placed in a watch glass with a few drops of water while being projected.

10. *Cloth Fibers*

Cloth fibers such as wool, cotton, silk, rayon, and linen, may be mounted on a single slide and projected as a comparative study. Very sheer and light weight material should be chosen. When very lightly stained in carmine or eosin and mounted in balsam these slides will be permanent. (Simple methods of staining and mounting will be sent on request by most supply houses). General science teachers will find this method of demonstrating cloth fibers very interesting as well as time saving.

11. *Miscellaneous Specimens*

Microprojection offers such an unusual means of projecting various things that to mention them all would be well-nigh impossible. Interesting specimens and objects that project especially well are:

a. Human hair. A comparative study is interesting.
b. Scrapings from the mucous membrane of the mouth. Allow to dry and stain in eosin.
c. Grains of sand, washed particles of dirt, silk, etc. Use a concave depression slide for these.
d. Tissue paper. Excellent to show way in which paper is made so far as texture is concerned.

The above are a few suggestions showing how a low cost microprojector has been successfully used. The ingenious demonstrator will find and use many other subjects.

To instruct and stimulate is always the teacher's prime objective. The microprojector as no other instrument, gives the student unforgettable moments in Biology and General Science and furnishes him with a desire for further study into the world of the minute.

A SELF-SUSTAINING CAMERA IN THE JUNIOR HIGH SCHOOL

By Harry C. Lassen
Foreman Junior High School, Chicago, Illinois

For the teacher who is a camera enthusiast it would be difficult to find a richer field for the exercise of his hobby than the junior high school. The socializing activities peculiar to the junior high, as vigorous, intense, and changeable as the groups themselves, present opportunities for making pictures faster than the "shots" can be made. Moreover, a certain amount of photography must be done for the school publications. It is this latter group, the "bread and butter" pictures, that makes possible the purchase and maintenance of a school camera.

FINANCING THE CAMERA

Let us say that a school spends $100.00 a year for pictures for the annual, the newspaper, the handbook, exhibits of school work. If one can borrow from school funds this hundred dollars and buy a photographic outfit, the required pictures can be delivered and the borrowed money repaid before a year has passed. Thus the school becomes owner of a camera at no expense, and gets more pictures than usual. This was done during the depression in an average school district. The secret lies in selling prints.

Every child welcomes an opportunity to buy a clear, permanent picture of his home room group. In the 5″×7″ size such a picture made by a professional would cost at least 25¢, but in the present plan it is sold at 10¢. There are, of course, other pictures than home room groups which are of sufficient permanent interest to warrant the purchase of a copy at 10¢. Among such pictures may be mentioned views of the library, the swimming pool, clubs at work, pupil-officials of the school, assemblies, election stunts, safety patrol, band, field-day drills, interesting class-room procedure, laboratories and shops in action; in short, anything interesting in which the pupils participate.

Some of the labor of making large numbers of prints may be obviated by having work done by quantity-printing specialists. We had 1000 post-card views of our building made for $25.00. We sold 500 of these painlessly at 5¢ each, paid the bill, and have 500 cards on hand. This remainder will be held until we know that it will be snapped up eagerly.

This may smack of commercialism, but we use no high-pressure selling methods. The children see a picture during a home-room period, learn the price, and buy entirely on their own volition. In some cases, where a number of different pictures are wanted by a group, samples are fastened to a drawing board, and a pupil chairman handles the ordering and collection. The painful differences of opinion so common in commercial transactions simply do not occur, because here all the anxiety is on the part of the buyer. No person is ever asked to buy; on the contrary, it is not at all easy to fill all the requests for pictures. After the outfit is paid for only enough selling need be done to provide for repairs and replacements in the equipment.

QUALITY OF NON-PROFESSIONAL WORK

A person who has had experience in taking and making kodak pictures and will devote several hours a week to photography can handle all the work for a school of 2000 membership. The first dozen pictures made are not likely to lead to a seige of scouts from the Louvre clamoring for copies, but sufficient skill in manipulating materials and arranging groups is acquired rather quickly. Our 'patrons' are not too critical, and an ordinary picture (just so it is in good focus) is better than none. Most of us would prize a picture of our classmates made "'way back when," even if it were a little less than artistic.

As soon as the amateur operator becomes familiar with his equipment he finds opportunities for making pictures which are not available to professionals. He is on the ground while the activity is occurring. He has access to every part of the building. He knows which rooms have the best natural illumination. He is not pressed for time: if the sun isn't shining he can wait. He knows the pupil-program, and can arrange to meet groups without excessive derangement of the school program. He can use school property such as high-wattage lamps from stereopticons. With all these advantages, it would be strange if the school photographer did not get pictures at least as good as commercial work.

ESSENTIAL EQUIPMENT

It is possible to buy a good second-hand 5″×7″ camera for about $20.00.
A second-hand lens and shutter costs at least $15.00. (With the rapid films now available, a lens with low f. value is not absolutely necessary.)
A second-hand tripod, $5.00
About six cut-film holders (each holds film for two exposures), $9.00

3 doz. spring clothes pins for hanging films while they dry, \$.30
Focussing cloth, \$1.50
One 5″×7″ printing frame. (A printing box to fit the frame can be made easily.) \$1.00
Four 8″×10″ trays, \$5.00
At least ten 14″×20″ ferrotype plates, the best you can afford to buy, at least, \$5.00
Flashlamp, \$2.00
Ruby lamp, \$.85
Print roller, \$1.00

Supplies

Chemicals (Use the science department's balance, metric weights and graduates for mixing.) \$15.00
Films, \$5.00
Paper, three degrees of contrast, \$10.00
1 doz. blotters, for ferrotyping, \$1.20

This makes a total of somewhat less than \$100.00. The last four items can be reduced to three or four dollars but it would be a poor economy to do so, and would require immediate profits to replenish the stocks.

Almost as useful as these materials are the numerous booklets, pamphlets, and formula cards which may be obtained free from manufacturers. One of the most useful of these is "Commercial Photo Finishing," obtainable from Eastman Kodak Stores Co., 133 No. Wabash Avenue, Chicago. The catalog of photographic materials published by The Central Camera Company, 230 So. Wabash Avenue, Chicago is an education in itself.

ADVANTAGES TO THE SCHOOL

Under this plan, the school obtains pictures at the cost of materials. As a result, school publications may be sold at a lower price, or may be enriched by vital material. Moreover, pictures are obtained which are useful in the numberless occasions which arise from day to day. The time when the junior high idea had to be sold to the public is happily past, but we can still very well present to our patrons evidences of the many socializing influences and educative processes of the school. It is doubted that any plan for directing attention to such ideas can be complete without pictures.

ADVANTAGES TO THE OPERATOR

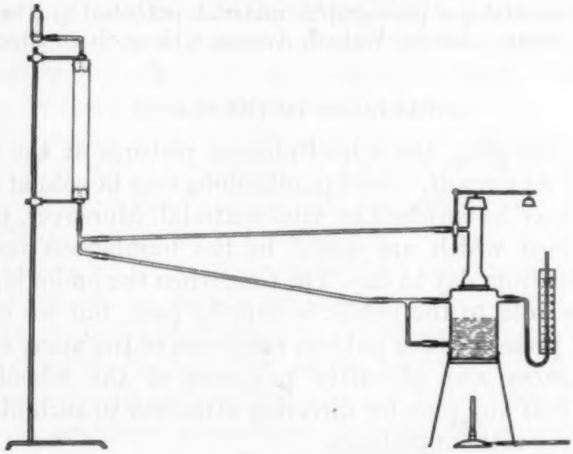
The operator develops skill and speed in the technical processes. He becomes familiar with modern photographic materials. His understanding and appreciation of artistic photography are enhanced. And finally, he may aspire to some degree of skill in the art.

A WORKING MODEL OF A STEAM HEATING PLANT

BY JOHN C. MAYFIELD
University High School, Chicago, Illinois

Models of steam heating systems are seldom mentioned in science teachers' literature although there are numerous descriptions of hot-water systems made from laboratory glassware. The model shown in the accompanying figure has been improved from year to year by boys in our general science classes until it is entirely satisfactory and requires no really difficult construction work. Embodying, as it does, every essential feature of a real "one-pipe" system, it has been unusually effective in demonstrating the principles and advantages of steam heating plants.

A standard steam generator was converted into the boiler of the model by placing a leather gasket between the steam chamber and the boiler and by substituting a properly bent T-tube for the usual gauge glass. Any convenient size of tubing may be used for the system except that nothing smaller than



eight millimeters, outside diameter, should be used in the one-pipe part. In a smaller tube the outgoing steam is apt to prevent the return of the water formed by its condensation. The steam line slopes gently to the point where it joins the return line, and, of course, the return line slopes back toward the boiler. The general plan of the model and the essential connections are clearly shown in the figure.

An inverted two-hole stopper was used for the safety valve. The holes in the stopper are plugged with pieces of glass tubing having the lower ends sealed and bent outward so that the stopper, while free to move up and down, cannot slip off the top of the steam chamber. Rods from two broken universal clamps make a good weight lever and support, the latter being fastened to the outlet tube of the steam chamber with a right-angle clamp. The weight lever rests on a short piece of triangular file laid on top of the rubber stopper. With a six-inch lever the weight used should probably not be more than ten ounces (or 300 grams).

The mercury manometer which serves as a pressure gauge is made of glass tubing small enough to slip inside the metal tube projecting from the right side of the boiler and is thus supported by it. The joint is sealed with a piece of live rubber tubing which is stretched over the end of the metal tube and yet fits tightly about the glass tube of the manometer. The scale of the gauge is a thin board with a V-shaped groove cut down the middle. Two pieces of rubber tubing glued in the groove hold the scale in place by their friction on the glass tube of the manometer, yet allow it to be slipped up or down to adjust the zero point. The divisions of the scale, indicating pounds of pressure per square inch, should be a very little more than one inch (1.018 inches) apart. With a 200-gram weight on the lever of the safety valve our plant operates up to a pressure of two pounds. If the joints are all air-tight it works quite well as a vacuum system when the burner is turned down. In fact, unless care is taken to break the vacuum when the heat is removed, the mercury may be forced over into the boiler.

The exact size of the glass radiator is immaterial. The rings or clamps used to support it should be set against the ends in such a way that the stoppers will not be forced out by the steam pressure. The air vent for our model cost twenty cents at a local hardware store and is the only part which was purchased especially for it. An ordinary pinch clamp may be used instead but, of course, will not be automatic. Additional radiators may easily be added along the steam line by inserting a T-tube for each one. To illustrate the arrangement for heating several floors, a vertical tube or "riser," with two or three radiators attached at different levels, may be connected in place of the single radiator shown in the drawing.

When the model is first shown to the pupils, a pinch clamp

is substituted for the automatic air vent, and the water is heated almost to the boiling point before the class enters. While the plant is getting up steam, attention is directed to the water-level gauge and to the pressure gauge which is beginning to rise. Steam soon begins to escape from the safety valve. Then a pupil is asked to test the effectiveness of the radiator by touching it cautiously. He reports that it isn't hot at all! The teacher affects real concern until some one suggests that the air be let out of the radiator. If such a suggestion is not made, the failure of the radiator to heat may be used as a real problem for the class to solve. Exactly the same difficulty was encountered with the first steam heating plants and the solution is said to have been discovered when one radiator developed a leak. When the "steam" begins to appear at the air vent the pupils are asked to look for the steam inside the radiator and steam line, thus directing attention to the fact that true steam is an invisible gas. Later the automatic air vent is replaced and its operation explained. Then the burner is adjusted and the model is left to operate without further care while the pupils examine it more closely and write their accounts of its operation.

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON,
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor, should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS OF PROBLEMS

Note.—Persons sending in solutions should read carefully the instructions about the form of the solutions and the ink-drawn figures. Many times, a good solution is received, but poorly arranged and no India-ink figure given. Contributors are requested to give their full address. This is for the convenience of friends of this department who write for this information.—Editor.

1234. *Proposed by Norman Anning, University of Michigan.*

Show that sin $2A$ is a rational number if sin A $-$cos A is a rational number.

Solution by Lester Dawson, Wichita, Kansas.

PROOF: $\sin A - \cos A$ is rational. Then, $(\sin A - \cos A)^2 = 1 - 2\sin A \cos A = 1 - \sin 2A$ whence $\sin 2A$ is a rational number.

Also solved by D. Moody Bailey, Athens, W. Va., and Chas. W. Trigg, Los Angeles, Calif.

1235. *Proposed by H. D. Grossman, N.Y.*

Find all the real roots of

$$x^2 - y = 2$$
$$y^2 - z = 2$$
$$z^2 - w = 2$$
$$w^2 - x = 2.$$

Solved by Norman Anning, Ann Arbor, Michigan.

Let $x = 2\cos A$,

then $y = 2\cos 2A$,

$$z = 2\cos 4A,$$
$$w = 2\cos 8A,$$
$$x = 2\cos 16A = 2\cos A.$$

There is a distinct real solution of the given set of equations for each value of A which satisfies the equation

$$\cos 16A = \cos A.$$

This equation is satisfied by sixteen and just sixteen different values of A, as follows:

$$n(2\pi/17) \text{ where } n = 0, 1, 2, 3, 4, 5, 6, 7, 8;$$
$$m(2\pi/15) \text{ where } m = \quad 1, 2, 3, 4, 5, 6, 7.$$

substitution of these values in the first four equations above yields the set of 16 real solutions of the given equations. Among the solutions are (2, 2, 2, 2) and (−1, −1, −1, −1). All of the solutions, when they are plotted as points in 4-space, lie on or within the "sphere"

$$x^2 + y^2 + z^2 + w^2 = 16.$$

Also solved by the proposer.

1236. *Proposed by L. W. Jones, Centerville, Iowa.*

Let a, b, c, d, denote four integers. Prove that the product of the differences $(b-a)(c-a)(d-a)(d-c)(d-b)(c-b)$ is divisible by 12.

Solved by W. E. Buker, Leetsdale, Pa.

If at least three of the integers are even, say, a, b, c, then $(b-a)(c-a)$ is divisible by $2\cdot 2$. Likewise, if at least three are odd, say a, b, c, then $(b-a)(c-a)$ is divisible by $2\cdot 2$. If two are odd, say a and b, and two are even, say c and d, then $(b-a)(d-c)$ is divisible by $2\cdot 2$. Thus, whatever the conditions, the given difference is always divisible by $2\cdot 2$. It remains to show that it is also divisible by 3. Consider the following:

Suppose we let $a = m$, $b = m + p$, $c = m + q$, $d = m + r$, where p, q, and r are integers. Then $(b-a)(c-a)(d-a)(d-c)(d-b)(c-b) = p\cdot q\cdot r(r-q)(r-p)(q-p)$, which we shall now show to be divisible by 3.

All integers are of the form $3m$, $3m+1$ or $3m+2$. If p, q, or r are of the form $3m$, then $p\cdot q\cdot r\,(q-p)(r-p)(r-q)$ is divisible by 3. If two, say p and q, are of the form $3m+1$, then $q-p$ is divisible by 3. If two, say p and q, are of the form $3m+2$, then $q-p$ is divisible by 3. But for the given in-

tegers p, q, r, either one or more is of the form $3m$, or else two are either of the form $3m+1$ or $3m+2$. Hence, we have established the fact that $p\cdot q\cdot r(q-p)(r-p)(r-q)$ is divisible by 3.

Therefore, $(b-a)(c-a)(d-a)(d-c)(d-b)(c-b)$ is divisible by $2\cdot 2$ and also by 3, and thus by 12.

Also solved by D. Moody Bailey, Athens, W. Va., and Albert Whiteman, Philadelphia, Pa.

1237. *Proposed by R. N. McGregor, Elk Grove, Calif.*

Construct a right triangle having given the sum of the base and hypotenuse and the sum of the side about the right angle

Solved by D. Moody Bailey, Concord College, Athens, W. Va.

(1) Let $b+h=m$ and (2) $b+a=n$

(3) In any right triangle $b^2=h^2-a^2$

Substituting in (3) the values of h and a as found from (1) and (2) and solving the quadratic formed gives

(4) $$b=n-m\pm\sqrt{2m(m-n)}.$$

Then geometrically we construct a mean proportional between $2m$ and $m-n$. Consider it as positive. Add n, and subtract m. After the determination of b, the construction of the triangle offers no further difficulty.

1238. *Proposed by Leo A. Aroian, Fort Collins, Colo.*

Find the asymptote to the Folium of Descartes:

$$x^3+y^3=3axy.$$

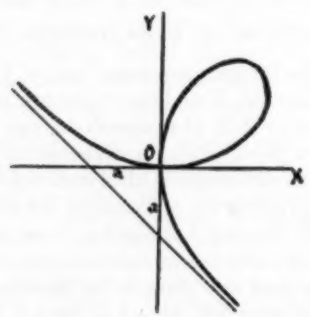
Solved by Charles W. Trigg, Los Angeles, Calif.

Let the equation of the asymptote be

$$y=mx+k.$$

Substituting in the equation of the folium, expanding and collecting terms.

FOLIUM-OF-DESCARTES



$$x^3+y^3-3axy=0$$

$$(m^3+1)x^3+(3m^2k-3am)x^2+(3mk^2-3ak)x+k^3=0.$$

Equating the coefficients of x^3 and x^2 to zero,

$$m^3+1=0, \text{ whence } m=-1$$
$$3m^2k-3am=0$$
$$3k+3a=0$$
$$k=-a.$$

Substituting these values in the general equation of the asymptote, the required equation is obtained,

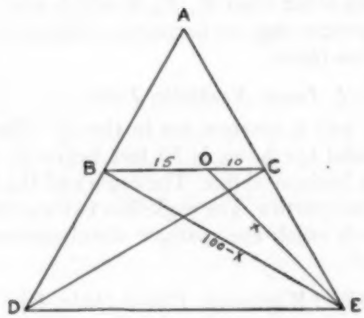
$$x+y+a=0$$

Also solved by W. E. Buker, Leetsdale, Pa., Polycarp Hansen, Collegeville, Minn., Lester Dawson, Witchita, Kans., D. Moody Bailey, Athens, W. Va., and the proposer.

1239. *Proposed by Harry Frye, Tallahoma, Tenn.*

ADE is an equilateral triangle. BC is parallel to DE. O is a point on the segment BC. $BO=15$, $OC=10$, $OE+DC=100$. Find the area of the triangle.

Solved by D. Moody Bailey, Concord College, Athens, W. Va.



Since $BCED$ is an isosceles trapezoid, $BE=DC$. Let $OE=x$. Then $BE=100-x$. Then from the triangles, BEC, and OEC, noting that the projection of BC on AC is $25/2$, we have

(1) $$(100-x)^2=625+y^2+25y$$

(2) $$x^2=100+y^2+10y.$$

Subtracting (2) from (1) and solving resulting equation gives

(3) $$x=\frac{1895-3y}{40}.$$

Substituting this value of x in equation (2) and clearing the fractions gives,

(4) $$1591y^2+27,370y-3,431,025=0.$$

From which $y=38.6267$, the desired root. Then

(5) $$AE=25+38.6267=63.6267.$$

And Area

$$(6) \qquad ADE = \frac{(63.6267)^2\sqrt{3}}{4} = 1752.94.$$

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

For this issue the Honor Roll appears below.

1229. M. H. Cohen, New Bedford (Mass.) H.S.

PROBLEMS FOR SOLUTION

1256. *Proposed by R. T. McGregor, Elk Grove, Calif.*

If a, b, and c be in harmonic progression, and n be a positive integer, show that $a^n+c^n>2b^n$ $(n>1)$.

1257. *Proposed by H. Grossman, New York City.*

Construct a triangle, given h_a, m_a, t_a.

1258. *Proposed by Norman Anning, University of Michigan.*

Find three integers other than K, K, K which are in arithmetic progression, geometric progression, or harmonic progression according to the order in which they are taken.

1259. *Proposed by S. I. Jones, Nashville, Tenn.*

An eagle, a hawk and a sparrow are in the air. The eagle is 100 feet above the sparrow and the hawk is 50 feet below it. The sparrow flies straight forward in a horizontal line. The eagle and the hawk start at the same time towards the sparrow. The eagle flies twice as fast as the sparrow. If the eagle and hawk reach the sparrow simultaneously, how far does each of the three fly?

1260. *Proposed by Albert Whiteman, Philadelphia, Pa.*

Determine a trapezoid such that the four sides, the altitude and the two diagonals are all integral.

ERRATUM

Problem 1247 in the November issue should read: Solve for x

$$x+\log_a x=a.$$

GERMS MORE HARMFUL FROM ACTIVE CASES THAN FROM CARRIERS

Amoebae, tiny parasites that cause one type of dysentery, have more disease-producing ability when they are taken from active cases of the disease than when they are taken from symptomless carriers. Likewise, these parasites are more potent for producing disease during an epidemic than when the infection is less active. These conclusions, based on studies of the parasite in kittens, were reported to the American Society of Tropical Medicine by Drs. Henry E. Meleney and William W. Frye of Nashville, Tenn.

AN EXPERIMENT ON THE HYDROGEN EQUIVALENT OF METALS

BY EUGENE W. BLANK, *Allentown, Pennsylvania*

The weight of a metal required to displace one gram of hydrogen is the hydrogen equivalent, or the chemical equivalent of the metal (1). The verification of this statement is a common laboratory experiment, the chemical equivalent being usually determined by measuring the volume of hydrogen liberated by the reaction between sodium metal and water, or zinc metal and dilute sulphuric acid (2), (3).

A very simple modification of the experiment enables one to simultaneously determine the chemical equivalents of two metals thus emphasizing the fact that although one gram of a given metal will always displace the same amount of hydrogen whatever be the liquid used, different metals furnish different amounts.

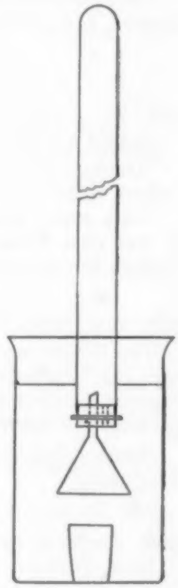


FIG. 1. Arrangement of Apparatus for Determining the Hydrogen Equivalent of Metals.

The apparatus used in the experiment is shown in Fig. (1). A saturated solution of zinc sulphate is placed in the small porcelain crucible and a weighed strip of magnesium ribbon placed in the solution. When the magnesium has been completely replaced by zinc the crucible containing the zinc metal is placed in a deep beaker, the beaker partially filled with water, a gas collecting tube inverted over the crucible and the experiment completed by adding sulphuric acid to the contents of the crucible by means of a pipet. From the data of the experiment the chemical equivalents of hydrogen, magnesium and zinc can be readily calculated.

LITERATURE CITED

1. Kahlenberg. *Outlines of Chemistry*, The Macmillan Co., New York City, 1909, p. 22, 61, 67.
2. Blanchard, *An Introduction to General Chemistry*, Doubleday, Doran and Co., Inc., New York City, 1928, p. 45.
3. Mellor. *Modern Inorganic Chemistry*, Longmans, Green and Co., New York City, 1922, p. 93.

SCIENCE QUESTIONS

December, 1932.

Conducted by Franklin T. Jones.

To Readers of School Science and Mathematics:
You are invited to propose questions for solution or discussion.
Send in answers to questions.
Examination papers are always desired, send in your own papers or any others. Tests and new things are wanted.
Please address all communications to Franklin T. Jones, 10109 Wilbur Avenue, S.E., Cleveland, Ohio.

FACT OR IMAGINATION?

610. An Employment Manager reports the following—Are they shop fables? Are there good scientific reasons to explain them?

"Dust sulphur into your shoes and in 24 to 72 hours you will have a yellow, or brown, "sulphur" stain under your armpits."

"In a round house the engine hostlers who clean out the engines walk in wet coal ashes. Their shirts and jumpers rot under their armpits as though burned with sulphuric acid."

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595. Who is the Engineer?

The Editor received a perfectly good logical answer proving that "Jones was the Engineer." It was scheduled for publication in this number of SCHOOL SCIENCE AND MATHEMATICS but has been mislaid. It will be a great favor if the sender of this solution will forward it again.

Another Solution from "ADSUM," *Chicago, Ill.*, proves that "Smith is the Engineer."

PHYSICS ACHIEVEMENT TEST

609. *Prepared by Walter E. Hauswald, Beardstown High School, Beardstown, Illinois.* (*Continued*)

PART TWO

Directions.—This section consists of statements some of which are true and some false. Read each statement carefully, and if true mark + in the space provided at the right. If false mark 0.

21. Sound travels faster in steel than in air. 21. ( )
22. The aneroid barometer does not contain a liquid. 22. ( )
23. The jack screw is one of the most efficient machines. 23. ( )
24. The voltage of the voltaic cell depends upon the area of the plates. 24. ( )
25. A body of specific gravity of two is just twice as heavy as water. 25. ( )
26. The coldest temperature thought possible is $-263°C$. 26. ( )
27. Pure water is one of the best conductors of electricity. 27. ( )
28. Water always boils at 100 degrees centigrade. 28. ( )
29. A good steam turbine is more efficient than a good reciprocating steam engine. 29. ( )
30. Sound waves are longitudinal waves. 30. ( )
31. A freely falling body falls exactly three times as far during the third second as during the first. 31. ( )
32. In passing from fresh to salt water a ship will rise slightly higher in the water. 32. ( )

33. The fulcrum of a lever is always near its center of gravity. 33. ( )

34. The mechanical advantage of a machine is equal to the resistance divided by the effort applied. 34. ( )

35. The period of a pendulum varies directly as the length. 35. ( )

36. Converging lenses are thicker at the center than at the edges. 36. ( )

37. The rate of evaporation is increased by a rise in temperature. 37. ( )

38. Sliding friction is directly proportional to the velocity of the moving surfaces. 38. ( )

39. White light is composed of many different rays of the same wave-length. 39. ( )

40. The time rate of doing work is called force. 40. ( )

41. When a room is heated by an open fireplace, heat is transferred from the fire to the room principally by the process of conduction. 41. ( )

42. Half as much light falls on your book when six feet from a light than when three feet from the same light. 42. ( )

43. When a person looks obliquely at a fish moving away from him in a pool of water, the fish appears to be ahead of its actual position. 43. ( )

44. Cohesion causes small particles of chalk to cling to the black-board. 44. ( )

45. When a watch is taken to a great height in an airplane its weight decreases slightly. 45. ( )

46. A boy inside of a car of a train moving with uniform speed throws a baseball vertically upward to the top of the car. When the ball comes down it will strike the floor of the car a little to the rear from the point where it was thrown. 46. ( )

47. A pendulum clock will run slightly faster on the top of a high mountain than at sea level. 47. ( )

48. At every point on the earth's surface a magnetic compass will point directly northward. 48. ( )

49. Storage batteries deliver direct current. 49. ( )

50. The larger the diameter of a standpipe, the greater the water pressure within the system. 50. ( )

51. Reflected sounds are seldom musical. 51. ( )

52. Galileo's experiments dealt with the behavior of falling bodies. 52. ( )

53. When a dry cell polarizes, its electromotive force is reduced. 53. ( )

54. When light originates in a body it is said to be illuminated. 54. ( )

55. The higher the pitch, the greater the velocity of a sound. 55. ( )

56. The tendency of wires carrying large currents to become heated is called induction. 56. ( )

57. A split ring commutator must be used on direct current generators. 57. ( )

58. The surface tension of mercury is quite great. 58. ( )

59. Accurate measurements of length may be made with the vernier caliper. 59. ( )

60. Torricelli's experiments were with static electricity. 60. ( )

Mr. Hauswald calls attention to the following correction in question 7 on page 795, School Science and Mathematics, October, 1932, issue:

"7. The weight of an object divided by its volume is called the. . . . . of the object."

611. *Proposed by Earl H. Schroer, Omaha Technical High School, Omaha, Nebraska.*

TEST ON MECHANICS OF FLUIDS

1. How many inches equal 1 meter? ....
2. How many pounds in 2 kgm.? ....
3. What is the mass of a liter of mercury? ....
4. Give the value of atmospheric pressure. ....
5. If a block contains 20 cc. and weighs 15 grams, what is the density of the block? ....
6. If the diameters of two pistons in a hydraulic press are 1 inch and 10 inches, how do their areas of cross section compare? ....
7. The water in a standpipe is 10 meters deep. What is the pressure (g./sq. cm.) on the bottom of the tank? ....
8. The density of lead is 11.4 g./cc. How many cc. of lead does it take to make a kg. weight? ....
9. The barometer reads 27.3 inches. What is its reading in cms.? ....
10. A stone weighs 42 grams in air and 25 grams in water. Find the density of the stone. ....
11. The water in a standpipe is 40 ft. deep. What is the pressure (lbs./sq. ft.) on the bottom of the tank? ....
12. A can weighs 190 grams empty, 500 grams when full of water and 613 grams when full of milk. Find the density of milk. ....
13. A dam is 50 ft. long and 6 ft. high and water just reaches the top. What is the total force against the side? ....
14. The density of stone is 2.5 g./cc. If a stone weighs 480 grams in water, find its weight in air. ....
15. If you can lift 156 lbs., how heavy a stone can you lift under alcohol if the specific gravity of the stone is 2.5 and the density of the alcohol is .825 g./cc? ....

Each question was given the value of the number of the question, making a total score of 120 possible. For 913 students taking the test the range was 120, the mean 57.37, the median 59.03, the first quartile 35.34 and the third quartile 74.74.

WANTED

Trick Questions! Send to Editor of Science Questions Department.

RECEIVED

Questions for future publication. Herbert S. Lein, North Tonawanda, New York; H. K. Moore, Thos. Edison School, Cleveland, Ohio; J. C. Packard, Brookline, Massachusetts.

BOOKS RECEIVED

Arithmetic for Teachers, by Harriet E. Glazier, Department of Mathematics, University of California at Los Angeles. First Edition. Cloth. Pages xv+291. 13.5 x 20.5 cm. 1932. McGraw-Hill Book Company, 330 West 42nd Street, New York, N. Y. Price $2.00.

The Metals, Their Alloys, Amalgams and Compounds, by A. Frederick Collins. Illustrated. Cloth. Pages ix+310. 12.5 x 19 cm. 1932. D. Appleton and Company, 35 West 32nd Street, New York, N. Y. Price $2.00.

Directed Studies for the Physics Laboratory, a manual to accompany Stewart, Cushing, and Towne's *Physics for Secondary Schools* by Burton L. Cushing, Head of the Department of Science, East Boston High School. Paper. Pages vi+168. 18.5 x 26.5 cm. 1932. Ginn and Company, 2301–2311 Prairie Avenue, Chicago, Illinois.

Workbook in Physics, by Samuel Ralph Powers, Professor of Natural Science, Teachers College, Columbia University, New York City, and H. Emmett Brown, Teacher of Science, Lincoln School of Teachers College and Instructor in Natural Science, Teachers College, Columbia University, New York City. Paper. Pages ix+294. 20 x 26.5 cm. 1932. Allyn and Bacon, 50 Beacon Street, Boston, Massachusetts.

My Addition Drill Book and My Subtraction Drill Book, by Guy M. Wilson, Professor of Education, Boston University. Paper. 21 x 28 cm. The Addition Drill Book has 62 pages and the Subtraction Drill Book has 54 pages. 1932. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price each 32 cents.

Microbe Hunters, by Paul De Kruif. Text Edition edited by Harry G. Grover, Dickinson High School, Jersey City, New Jersey. Cloth. Pages xiii+368. 12.5 x 19 cm. 1932. Harcourt, Brace and Company, Inc., 383 Madison Avenue, New York, N. Y. Price $1.20.

Mathematische Statistik und Biometrik, by Dr. P. Riebesell, A. O. Professor an der Hamburgischen Universitat. Board. 59 pages. 13 x 19 cm. 1932. Otto Salle, Berlin und Frankfurt am Main.

General Biology, by Frank Merrill Wheat, Chairman, Department of Biology, George Washington High School, New York, N. Y., and Elizabeth T. Fitzpatrick, Chairman, Department of Health Education, George Washington High School, New York, N. Y. Cloth. Pages viii+566. 13 x 20 cm. 1932. American Book Company, 330 East 22nd Street, Chicago, Illinois.

BOOK REVIEWS

Fundamentals of Insect Life, by C. L. Metcalf, Professor of Entomology in the University of Illinois, and W. P. Flint, Chief Entomologist, Illinois State Natural History Survey, and Entomologist of the Illinois Agricultural Experiment Station. First Edition. Cloth. Pages xi+581. 14.5 x 23 cm. 1932. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York, N. Y. Price $4.00.

This book is a natural outgrowth of an earlier work, *Destructive and Useful Insects,* by the same authors, and represents an improved treatise on general entomology. The book is designed to meet the needs of both the student who is entering upon a specialized career in entomology or a related field of biology, and at the same time to supply a general appreciation of insect life to the student who is unable to devote a major part of his time to biology, but who desires this knowledge as a part of his educational equipment for life.

The content is made up of orthodox material. Two chapters open the book with a discussion of beneficial and deleterious effects of insects upon the life and activities of man. The next four chapters present a discussion of the anatomical, physiological, and developmental features of the subject. Most of the important orders and families of insects are taken up in a separate chapter, and references are given for the identification of specimens, although no keys are presented in the text. Two chapters are given over to the economic side of entomology, and an outline of control methods

presented. The last two chapters present an excellent account of the ecology and behavior of insects.

Fundamentals of Insect Life is readily adaptable as a reference work for the average course in general biology and supplies a wealth of material usually omitted from such courses, and at the same time forms a text of adequate scope for more specialized work in entomology.

JESSE F. SCHUETT

Education for Business, by Leverett S. Lyon, Director of Educational Activities and Public Relations, The Brookings Institution, Washington, D.C. Pages xvi+586. The University of Chicago Press, Chicago, 1931.

Of late a large number of publications and texts deal with problems of business education, but few approach this subject from the scientific and analytical point of view as does the author in the above mentioned text.

He surveys the existing methods and trends of business and education in general, and then goes on to integrate these influences into a scientific approach of curriculum construction in this field. What is business? What is the specialization of business units? What is the science, organization, construction, and supervision of business? These and other related questions the author attacks with data from which he gathered from primary sources.

As a source book for counsellors in the educational and vocational guidance field, this book is excellent. Especially is this true for the teacher or student who is dealing with the commercial subjects. An insight into the methods concerned in the teaching of the various commercial subjects, how these subjects grew in importance, their present status, how a curriculum should be constructed, the management, supervision, and philosophy of the entire commercial field is considered in relationship to education, and from the point of view of a gifted educator.

HAROLD E. ZLATNIK

Methods in Plant Histology, by Charles J. Chamberlain, Professor Emeritus of Morphology and Cytology in the University of Chicago. Fifth Revised Edition. Cloth. Pages xiv+416. 14.5 x 22 cm. 1932. The University of Chicago Press, Chicago, Illinois. Price $3.25.

This fifth edition of *Method in Plant Histology* has brought this standard book on plant histology up to date as to the latest methods of technique. Not only this, but the book has been entirely rewritten and considerable new matter added. There is a new chapter on "Illustrations for Publication" and the chapters on "Paleobotanical Microtechnique" and on "Laboratory Photography" have been amplified.

The book has been so carefully written that amateur students away from the aid of instructors may carry on the work successfully, especially since the second part of the book contains specific directions for the study of all the more important plant forms from the Myxomycetes to the Angiosperms. The illustrations are numerous and of the most helpful sort made especially for use in this work. In every way the work on the book is to be highly commended—we refer to the work or the printer as well as to that of the author and his associates.

W. WHITNEY

The Elements of Physics, by Alpheus W. Smith, Professor of Physics, The Ohio State University. Third Edition. Cloth. Pages xviii+778.14 x 23 cm. 1932. McGraw-Hill Book Company, 330 West 42nd Street, New York, N.Y. Price $3.75.

This book first appeared in 1923 as *Elements of Applied Physics*. It was

revised in 1927 as *Elements of Physics* and now is brought up to date by a third edition. This edition is in many respects a new book embodying the important attributes of the former editions but with many sections re-written and over a hundred pages added. The new subject matter consists largely in additions to the sections on the kinetic theory of gases, radiation, electromagnetic waves, spectra and color phenomena, series in optical spectra and the quantum theory. Many of these topics now form complete chapters. In other cases new paragraphs on recent developments have been added. Many new problems have also been added and old ones revised. Considerable improvement has also been made in the order of presentation.

The important characteristics of the text may be briefly summarized—thus: (1) clear discussions of important fundamental principles in easily comprehended language; (2) absence of advanced mathematics; (3) many illustrative numerical problems with their solutions and an abundance of problems for student work; (4) discussions of practical applications drawn from a variety of sources including farm, shop, transportation, other sciences, etc.; (5) short chapters, many diagrams, graphs, and photographs. This text is now well abreast of the time; it encourages students to understand physical principles; it does not assume that students will have much previously acquired knowledge of physics or college mathematics. Use of a textbook is the only satisfactory way to discover its true characteristics, yet this one has so many outstanding virtues that the reviewer does not hesitate to say it is excellent, and to recommend its adoption.

G. W. W.

An Arithmetic for Teachers, by William F. Roantree, Jamaica Teacher's Training College, and Mary S. Taylor, New York Teachers' Training College. Revised Edition. Pages X+523. 13 x 19 cm. 1932. The Macmillan Company. Price $2.50.

This book is particularly adapted for use as a text in a special methods course. It is a revision of the 1925 edition by the same authors. In the preface they remark that the chapters on "Factors and Multiples" and "Powers, Roots, and Exponents" have been omitted and that addition and subtraction are treated in one chapter since these processes are so closely related in teaching. Likewise, the chapters on multiplication and division have been merged.

The organization of the material is clear cut and seems very desirable. Each chapter is divided into two distinct parts. The first part under the subject "Teacher's Knowledge" gives some history of the topic and a discussion of the concepts, terms, processes, and facts necessary for an understanding and appreciation of the topic. A list of exercises follows this discussion. Many of these are purely arithmetical exercises, practice material for developing ability and skill. The second part of the chapter is devoted to a discussion of the methods of teaching the particular topic. This part is also followed by a list of exercises devised to aid the student in his comprehension of the material.

The materials chosen for the text are well adapted for the purpose. The book should prove stimulating and useful to teachers of experience as well as valuable for use as a text in a methods course.

G. E. Hawkins

Mathematics of Finance, by H. L. Rietz, University of Iowa, A. R. Crathorne, University of Illinois, and J. Chas. Rietz, Actuary of the Midland Mutual Life Insurance Company. Revised Edition. Pages xv+

346. 12.5 x 19.5 cm. 1932. Henry Holt and Company, One Park Avenue, New York, N.Y. Price $3.00.

In this revised edition the authors have extended the tables of compound interest and annuities. In the first edition there are 25 pages of tables, while in the second, there are 57 pages. The number of problems has been nearly doubled.

The text has been modified to some extent. Thus, the first chapter in the first edition on simple and compound interest has been broken up into two chapters, one on simple interest, the second on compound interest. The chapter on annuities certain has been divided into two chapters, one on simple cases and the other on complex cases. The chapters on life annuities and insurance have been extended by additions of sections on valuations by the Illinois Standard Method, the New Jersey Standard Method, and the Select and Ultimate Method.

The material is presented in such an elementary form that students with no more training than one half year in college mathematics can read it.

J. M. Kinney

Differential and Integral Calculus, by John Haven Neelley, Ph.D., Professor of Mathematics in the Carnegie Institute of Technology, and Joshua Irving Tracey, Ph.D., Associate Professor of Mathematics in Yale University. Pages viii+496. 14.5 x 19.5 cm. Cloth. 1932. The Macmillan Company, 60 Fifth Avenue, New York, N.Y. Price $4.00.

The authors have designed this book to meet the needs of both the academic and the engineering student. The first two chapters and the eighth chapter deal with analytic geometry which may be read by students who need to review this subject. Throughout the text we find numerous sets of problems which give the student an opportunity to apply the theory to concrete situations in science and geometry. The material seems to be well organized and it is presented in an attractive style.

J. M. Kinney

Solid Geometry, by D. Meade Bernard, Head of Department of Mathematics, Robert E. Lee High School, Jacksonville, Florida. Pages lix+202. Johnson Publishing Co., New York, 1932. Price $1.24.

This book on solid geometry has many interesting features. At the beginning of each chapter will be found charts which contain figures of all the propositions included in the chapter in the order in which they occur in the text. In this way the student is enabled to grasp the subject of the chapter as a whole and is provided with the proper motivation. It also shows how the subject is developed and shows relationship between the various parts of each chapter.

In addition to the above the author introduces what he calls the "Method of Proof" feature. This consists in giving, in a few words, a simple statement of what the method of proof is to be, before the formal proof is introduced. The advantage of this procedure is obvious to the teacher of mathematics.

There are a great number of illustrations which are well drawn and many original exercises. At the end of the book will be found two hundred fifteen supplementary exercises taken from examination papers from thirty-four leading universities and colleges.

Teachers of solid geometry will find many novel features in this book.

C. A. Stone

Solid Geometry, by Herbert E. Hawkes, Professor of mathematics in the Columbia University, William A. Luby, Head of the Department of Mathematics in the Junior College, Kansas City, and Frank C. Touton Professor of Education, University of Southern California. New Edition. Pages xvi+216. Ginn and Co. 1932. Price $1.24.

This book is a revision of a former edition, and while no drastic changes have been made, a few definitions have been rephrased, the order of theorems has been improved, numerical exercises have been modified, and some new type test material has been added. The reviewer feels, however, that the test questions should follow each chapter in appropriate order.

The material is presented in such a way that a minimal course as prescribed by colleges and examining boards may be covered, and in addition provision may be made for the accelerated pupil.

The teacher will find a great variety of exercises and many originals that the average pupil can do successfully, thus making for encouragement. There are also a number of exercises to challenge the more powerful pupil. There are also a great number of illustrations and a good selection of supplementary material.

This book should prove interesting to teachers of solid geometry.

C. A. STONE

FIND FEVER TREATMENT RELIEVES STUBBORN ASTHMA

Artificial fever, which has been helpful in treating paresis is now being turned to the treatment of another ailment, chronic asthma. Thirty cases of the disease in which relief was obtained by this means have been reported to the American Medical Association, by Drs. Samuel M. Feinberg, Strafford L. Osborne, and Meyer J. Steinberg, of Northwestern University Medical School.

In nineteen of these patients the relief of symptoms was complete and lasted from several days to nine and one-half months. In the other eleven cases, there was improvement without complete remission of the symptoms.

The fever was induced in these patients by high frequency electric currents, or diathermy. In all of the cases, other means of treating asthma had been tried without success. Careful examination of the patients before using this form of treatment is essential, it was emphasized, as not all patients might be able to stand it.

LACK OF VITAMIN A IN DIET MAY BE CAUSE OF KIDNEY STONES

Evidence that lack of vitamin A in the diet may be the cause of kidney stones has been reported by Drs. C. A. Elvehjem and V. F. Neu of the University of Wisconsin. These investigators found that in birds the kidneys undergo definite, harmful changes when the birds are deprived of vitamin A.

Other investigators, Drs. T. B. Osborne and L. B. Mendel in this country and Dr. Robert McCarrison in England, observed a similar relation between kidney stones and lack of vitamin A in laboratory animals. Recalling that kidney stones are particularly prevalent among peoples of the Far East, Dr. McCarrison fed animals on diets made up of foods common in India. More than one-fifth of the animals developed kidney stones. When vitamin A was added to their East Indian diet, the animals did not have kidney stones.

TEXAS MAY HAVE HAD GLACIERS IN COAL AGE

Glaciers great enough to transport heavy boulders may have crunched their slow way across Texas landscape millions of years ago, during the Coal Age. Evidence to the effect has been found in the western part of the state, in the Trans-Pecos region, by Charles Laurence Baker of the University of Texas, whose detailed report will be published in the forthcoming issue of the Journal of Geology.

The evidence consists largely of boulders of the same general type as were transported by the vast continental glaciers of the pleistocene period, millions of years later—almost yesterday, as compared with the antiquity of the Coal Age. Mr. Baker does not think his Coal Age boulders were necessarily carried by continental glaciers, however. There were mountains in West Texas then, he points out, and they could easily have been lofty enough to bear alpine glaciers of their own.

Nor would such mountain glaciers have interfered with coal formation, he believes, calling attention to the presence of coal beds in India and in the Southern Hemisphere, close to glacial deposits, while in New Zealand and Chile rich vegetation, including even tree ferns, can be found within a mile of glacier fronts.—Science Service.

NEW CHEAP SOURCE OF VITAMIN A TO AID RESEARCH

Carotene, from which the body derives vitamin A, is now available to physicians and scientists at about half its former cost as a result of research conducted by Dr. A. F. O. Germann and Dr. Harold M. Barnett of the S.M.A. Corporation research laboratory.

Efforts to isolate vitamin A itself have been hampered by the scarcity and high cost of pure crystalline carotene, the provitamin A. This substance once cost approximately $11,000 a pound. By the new process it is possible to market it for research purposes at less than $7,000 a pound.

Besides providing scientists with a cheaper source of carotene for investigation, the new method of producing crystalline carotene will enable physicians to give it to their patients in addition to the vitamin A in the diet, as they now can give viosterol as an extra source of vitamin D.

Vitamin A is necessary for normal growth, prevents the development of a certain type of eye disorder and has lately been said to have power to increase resistance to infections such as colds. It is found in cod liver oil and in a number of foods, chief among them being butter, carrots, cream, eggs, milk, spinach and watercress.

NEW RIVER ADDED TO MAP OF SOUTH AMERICA

A new river, the Rio Brown, will appear on the future maps of South America as a result of exporations by the Ulrich Expedition. Otto W. Ulrich, leader, named it in honor of Dr. William Moseley Brown of Ballston, Virginia, who with several other sponsors has made the expedition possible.

The Rio Brown rises in the deep interior of Brazil, and flows westward into the Araguaya, which eventually reaches the sea through the great estuary of the Para river. In its upper course the newly discovered river approaches the headwaters of the Rio Xingu, where the lost explorer Fawcett was last heard of.

In reaching the new river, the Ulrich Expedition has traversed many hundreds of miles of jungle watercourses part of the way through lands of hostile Indians, who killed two native members of the party. They also had their troubles with wild beasts; Mr. Ulrich shot seven jaguars, all black. His report was brought back to the coast by a messenger who required many weeks for the journey.

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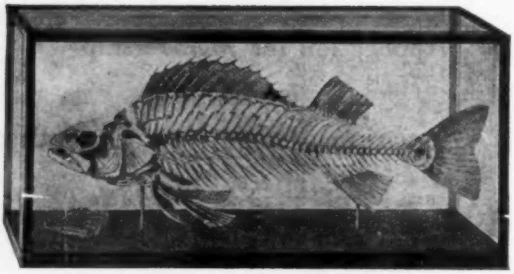
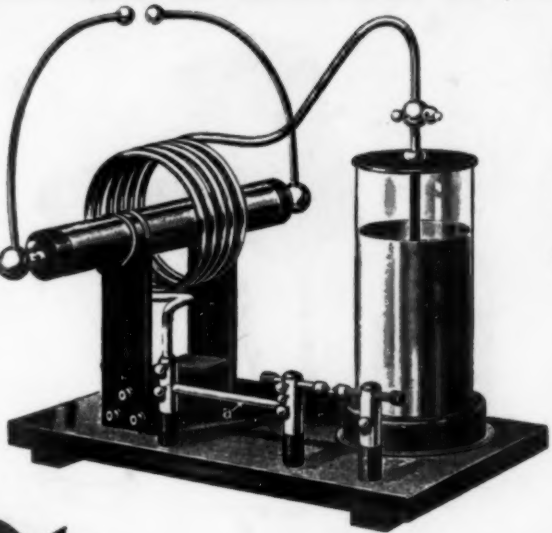


Skeleton of Fish in Case

Model of Human Heart. Dissectible



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